JOHN F. KENNEDY SPACE CENTER

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RISK MANAGEMENT TECHNIQUE FOR DESIGN & OPERATION OF LIQUEFIED NATURAL GAS FACILITIES & EQUIPMENT

- NASA CR–139183

- **RISK MANAGEMENT TECHNIQUE FOR DESIGN AND OPERATION OF LIQUEFIED NATURAL GAS FACILITIES AND EQUIPMENT**

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16. Abstract

This project, sponsored under the NASA Technology Program, is to develop a risk management and facilities certification methodology applicable to liquid natural gas faciliies at the Nation's port cities. NASA and The Boeing Aerospace Company at the Kennedy Space Center are working with the New York Fire Department to apply techniques derived from their experience in management of space program hazardous materials facilities.

This report contains data prepared between the period of June 1, 1974 and December 31, 1974. It is presented in the following four sections:

(1) Review of NYFD, "Regulation for Manufacture , Storage, Transportation, Delivery and Processing of LNG,
(2) Proposed Risk Management Provisions for the Design, Fabrication and Operation of LNG Facilities.
(3) Preliminary Operating Instructions–Risk Management System for LNG".
(4) Preliminary ADP Requirements for RMS

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Preface

The scope of the project is to develop a risk management and facilities certification methodology applicable to liquid natural gas (LNG) facilities. The Kennedy Space Center (KSC) and the Boeing Aerospace Company with their experience with management of hazardous materials facilities have worked with the New York Fire Department in applying these risk management and certification techniques to new facilities in planning and/or construction for New York City.

The potential of this management technology, if demonstrated to be acceptable as an application for New York City, is its widespread use by the Nation's port cities which are also faced with LNG safety problems.

Background

This work was initiated under Task Order 7200-0143-74 in February, 1974, and continued under Supplemental Agreement #63 to Contract NAS10-7200, dated June 1, 1974. Otto H. Fedor, KSC/DE-SED-3 was designated NASA Technical Representative. William N. Parsons, Clyde E. Medkief and Arthur W. Niergarth of Boeing Aerospace Company, performed the effort at Kennedy Space Center, Florida. The effort was also supported throughout by Messrs. William L. Smith, NASA Technology Utilization Office, James O. Harrell, AA-PAT, KSC and Todd Anuskiewicz, Informatics TISCO Inc. Coordination trips were made to New York City during May, July, August, September and November during which facilities at Brooklyn Union Gas, Consolidated Edison, Distrigas, and Texas Eastern were visited. New York City Fire Department personnel who were directly involved in the coordination were:

James Love - Chief Fire Prevention, NYFD
John F. McGowan - Deputy Chief Fire Prevention, NYFD
Milton Fishkin - Chief Inspector, NYFD
David E. Rosenstroch - Deputy Chief Inspector, NYFD

On September 12, 1974, the project was reviewed by John T. O'Hagen, Commissioner, NYFD.

Summary

This report covers the activities thru December 31, 1974, in which the basic concepts of the Risk Management System were developed. The report has been divided into four sections:

Section I - NYFD Regulation
Section II - Appendix A to the NYFD Regulation (Risk Management Provisions)
Section III - Operating Instructions - RMS
Section IV - Preliminary ADP Requirements

Summary (Cont'd)

Figure 1 shows the relationships of these documents and a brief summary of each follows.

Section I - NYFD Regulation

The first task of the study effort was to review the proposed "Regulation for Manufacture, Storage, Transportation, Delivery and Processing of Liquefied Gas" prepared by the New York Fire Department. A comprehensive review of related codes and standards was conducted, along with a review of applicable KSC and Boeing experience in the operation of cryogenic facilities. Recommendations for revision were provided to the New York Fire Department in the form of a revised draft dated August 1, 1974. This draft is included as Section I.

Section II - Appendix A to the NYFD Regulation (Risk Management Provisions)

One of the basic problems facing the Fire Department in operating a Risk Management System was how to get the owner of a facility to understand and to support Risk Management System requirements and operations. The method recommended was to provide, as an appendix to the regulation, a set of "Risk Management Provisions" to be followed by the owner. The document included as Section II provides this basic description of the system and sets down general guidelines to be followed by the owner in supporting NYFD Risk Management.

Section III - Operating Instructions - NYFD Risk Management System for LNG

The Operating Instructions document was prepared as the guide for Fire Department personnel who would be operating the Risk Management System. It contains working level descriptions of the basic concepts and the step-by-step instructions for preparing the data to be handled and the procedures for status reporting and control. A significant element of the operating instructions is the Project Review. The Project Review is the culmination of the Project Phases under the RMS.

Section IV - Preliminary ADP Requirements

It is recognized that automatic data processing is highly desirable to give the RMS responsive reporting and control information. Current New York City ADP systems were not investigated during this study because the Fire Department is in the process of developing a "Management Information and Control System" (MICS) which will provide within the Fire Department, the capability of data to support the RMS. Section IV contains a set of preliminary Automatic Data Processing requirements which are included to support MICS planning. The RMS can be implemented in a manual mode and operated for a period of time to establish the basic requirements of the Fire Department. These should then be matched to the data processing capability of the Fire Department for the most effective operation.

RISK MANAGEMENT SYSTEM DOCUMENT TREE

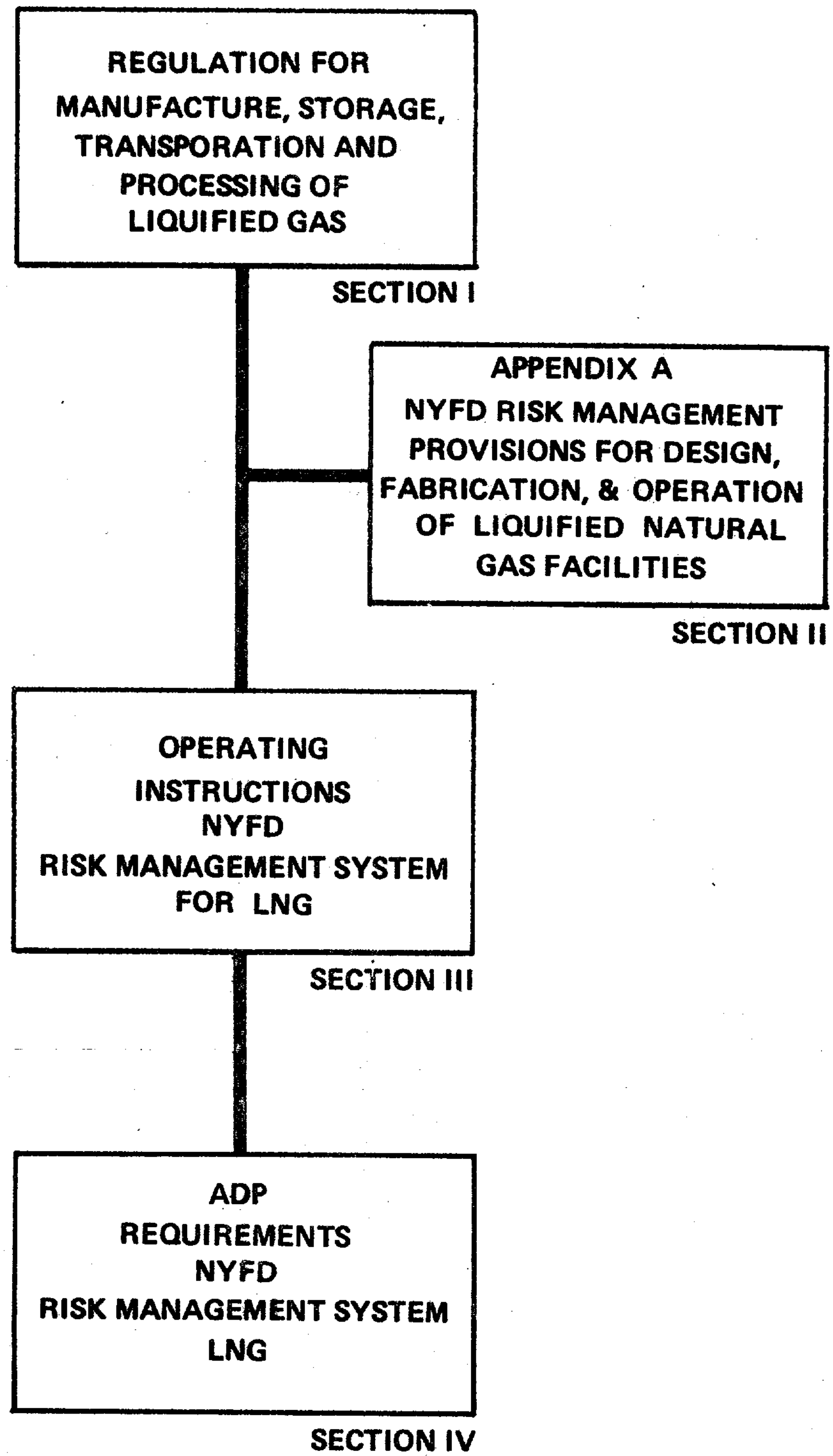

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FIGURE 1

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SECTION I

REGULATION FOR

MANUFACTURE, STORAGE,

TRANSPORATION AND PROCESSING

OF

LIQUEFIED GAS

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REGULATION FOR MANUFACTURE, STORAGE TRANSPORTATION, DELIVERY AND PROCESSING OF LIQUEFIED GAS

AUGUST 1, 1974

SECTION I

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LIST OF ILLUSTRATIONS

1. AUTHORITY

These regulations are promulgated under the authority of the Fire Commissioner as provided in Section 489 of the Charter.

2. SCOPE

These regulations shall apply to all liquefied natural gas installations constructed and operated after the date of promulgation and to the operation, alterations or redesign of existing facilities. These rules shall be applicable also to the waterborne transportation and delivery of LNG. In all matters not specifically provided for herein, the Regulations of the Department of Transportation and the Public Service Commission of the State of New York, and NFPA STD 59A, 1972 shall apply.

3. DEFINITIONS

3.1 AGENCY HAVING JURISDICTION:

The local authority having responsibility as prescribed in the Charter and Administrative Code of the City of New York, e.g., Fire Department, Department of Buildings, Department of Ports and Terminals.

3.2 APPROVED:

Sanctioned by the agency having jurisdiction for use or operation, after inspection, test or acceptance of data supporting the safety and/or effectiveness of the design, equipment or process.

3.3 BARGE (LNG):

A vessel, with or without its own propulsion system, inspected and approved by the U.S. Coast Guard for transportation and delivery of LNG on waterways within the Port of New York.

3. DEFINITIONS (CONTINUED)

3.4 BARREL:

A unit of volume equal to 42 U.S. gallons.

3.5 BERM:

A concrete or compacted earth structure constructed directly against or closely surrounding the container to a height 10% in excess of the design liquid level to serve as the primary impounding area.

3.6 DERIMING: (Defrosting or Deicing)

The removal by heat and evaporation, sublimation, or solution of accumulated constituents which form solids, e.g., water and CO_2 from the low temperature process equipment.

3.7 DESIGN PRESSURE:

The pressure used in the design of equipment, container or vessel for the purpose of determining the minimum permissible thickness of physical characteristics of its different parts. When applicable, static heads shall be included in the design pressure to determine the thickness of any specific part.

3.8 DIKE:

A compacted earth, a concrete, or other non-combustible structure used to establish an impounding area suitable for containing the fluids involved.

3. DEFINITIONS (CONTINUED)

3.9 FAIL SAFE:

The design feature which provides for safe condition in the event of malfunction of control devices, detection of fire or gas leak, or interruption of an energy source.

3.10 IMPOUNDING AREA:

An area which limits by dikes or natural topography, the containment of spilled LNG, flammable refrigerants or other low flash liquids.

3.11 INCOMBUSTIBLE OR NON-COMBUSTIBLE

A material which, in the form in which it is used in construction, will not ignite and burn when subjected to fire. However, any material which liberates flammable gas when heated to any temperature up to 1380 degrees Fahrenheit for five minutes shall not be considered noncombustible. No material shall be considered noncombustible which is subject to increase in combustibility beyond the limits established above, through the effects of age, fabrication or erection techniques, moisture, or other interior or exterior atmospheric conditions.

3.12 INSTALLATIONS:

Includes tanks, liquefaction and vaporization facilities, processing equipment, piping and associated loading and unloading facilities, and all fire protection.

3. DEFINITIONS (CONTINUED)

3.13 LIQUEFIED NATURAL GAS (LNG):

A gas in the liquid state composed predominately of methane and which may contain minor quantities of ethane, propane, nitrogen or other components common to natural gas.

3.14 MAXIMUM ALLOWABLE WORKING PRESSURE:

The maximum gage pressure permissible at the top of completed equipment, container or vessel in its operating position for a design temperature.

3.15 PRIMARY COMPONENTS:

Primary components, in general, include those whose failure would permit leakage of the liquid being stored, those exposed to a refrigerated temperature between -60F and -270F, and those subject to thermal shock. The primary components shall include, but will not be limited to, the following parts of a double-wall tank; shell plates, bottom plates, knuckle plates, compression rings, shell stiffeners, manways, and nozzles including reinforcement, shell anchors, pipe, tubing, forgings and boltings on both inner and outer tank and the roof plates of the inner tank. All LNG liquid and vapor piping and fittings shall be considered primary components.

3.16 PROCESS EQUIPMENT:

All systems required to condition, liquefy, or vaporize natural gas in all areas of application referred to in these regulations.

3. DEFINITIONS (CONTINUED)

3.17 PSIA: Pounds per square inch absolute.

3.18 PSIG: Pounds per square inch gage.

3.19 RISK ANALYSIS:

A methodology of assessment of an identified hazard utilizing a systematic evaluation of failure modes, probabilities and consequences resulting in quantitative data supporting recommendations for corrective action.

3.20 SECONDARY COMPONENTS:

Secondary components, in general, include those which will not normally be in contact with the refrigerated liquid being stored, those exposed to product vapors and having a design metal temperature of -60°F or higher.

3.21 TANKER (LNG):

An ocean-going vessel, inspected and approved by the U.S. Coast Guard for the transportation and delivery of LNG to approved facilities in the Port of New York.

3.22 SERVICE BUILDING:

A building used for office, maintenance, shops, electrical distribution, garage or storage.

3.23 TANKS:

3.23.1 LNG Storage Vessels - LNG vessels or containers of more than 2500 gallons capacity operating at not more than 2.5 PSIG.

3.23 TANKS: (Continued)

3.23.2 Process, Satellite, or Similar Tanks - LNG vessels or containers with a capacity of 2500 gallons or less.

4. PLANT SITE

4.1 MINIMUM CLEARANCES

Minimum clearances shall be maintained between LNG containers, flammable refrigerant storage tanks, flammable liquid storage tanks, buildings, structures and plant equipment and plant property lines as prescribed in the chart of minimum distance requirements (Figure 1), unless otherwise provided in these regulations. Siting of tanks shall further be based on radiation and vapor dispersion studies made by competent authorities prior to approval of site plans in order to establish the minimum distance of the property line and to critical occupancies.

4.1.1 Thermal Radiation and Vapor Dispersion Study

A thermal radiation and vapor dispersion study shall be submitted, prepared by recognized experts in thermodynamics acceptable to the Fire Department. The study should include vapor dispersion characteristics resulting from spills caused by major failure modes of the storage tanks, equipment, and piping. The study should show equilibrium temperatures within a radius of 1500' of the tank, at wind velocities of 0, 30, and 60 mph, at points where R = 1500', 1200', 1000', 800', 600', 500', 400', 300', 200' and 100' from flame surface (innertank wall) in events where an entire tank or group of tanks are involved in a fire. Attention shall also be given to the possibility of local overheating and fires in impounding areas.

MINIMUM DISTANCE
(Feet)

	LNG CONTAINER	IMPOUNDED LIQUID	PROCESS EQUIPMENT [6]	VAPORIZERS	PROCESS CONTR. HOUSES	FIRE PUMP HOUSE FIRE PROT. CONTROL	MARINE TRANSFER FACILITIES	CRITICAL OCCUPANCY	SERVICE BUILDINGS	PROPERTY LINE OR NAVIGABLE WATER	BOIL-OFF COMPRESSORS	FLARE STACKS OR IGNITION SOURCE	SEWERS, UNDERGRD DUCTS, DRAINS
LNG CONTAINER	[2] 250		[5] 250	[5] 250	500	500	[5] 250	[1] 1000	250	[2] 250	100	[2] 250	500
IMPOUNDED LIQ.			150	150	[2] 250	500	250	[1] 1000	250	[2] 200		250	50
PROCESS EQUIPMENT [6]	[5] 250	150		100	[3] 100	200	250	250	100	100		100	
VAPORIZERS	[5] 250	150	100		200	200	250	250	200	100	100	100	
PROCESS CONTR. HOUSES	500	[2] 250	[3] 100	200			250	150	100		100	250	
FIRE PUMP HOUSE FIRE PROT. CONTR.	500	500	200	200			200	100	100		100	250	
MARINE TRANS. FACILITIES	[5] 250	250	250	250	250	200		1000	[4] 100	100	200	250	
CRITICAL OCCUPANCY	[1] 1000	[1] 1000	250	250	150	100	1000				100	250	
SERVICE BUILDINGS	250	250	100	200	100	100	[4] 100				100	100	
PROPERTY LINE OR NAVIGABLE WATER	[2] 250	[2] 200	100	100			100				100	100	
BOIL-OFF COMPRESSOR	100			100	100	100	200	100	100	100		100	
FLARE STACKS OR IGNITION SOURCE	[2] 250	250	100	100	250	250	250	250	100	100	100		
SEWERS, UNDERGRD DUCTS, DRAINS	500	50											

Figure 1

NOTES:
1. Hospitals, schools, places of assembly, bridges, tunnels etc.
2. Or one and a quarter tank diameters, whichever is greater, except that tanks of not more than 2500 gallons shall be spaced according to the diameter criteria, but not less than 100 feet.
3. Except where a four-hour unpierced wall seperates the Control Room from flammable liquid handling and explosion venting is provided.
4. For vessels up to 30,000 bbls. cap., increase to 200 feet for vessels up to 50,000 bbls., and increase to 300 feet for vessels in excess of 50,000 bbls.
5. Or one tank diameter, which ever is greater.
6. Includes cold box.

4. PLANT SITE (CONTINUED)

4.2 SITE PLANS

4.2.1 Proposed Site Plan

A proposed site plan shall be filed with the Fire Department indicating all major characteristics of the site, showing plant buildings, tanks, containers, dikes, process areas, transfer areas, major LNG piping, lot lines, shore lines, and exposures within 1500' of lot lines. Such aerial photos as the Fire Department may require shall be included. Site plans shall include underground channels, such as conduits, pipelines, drainage ditches, and similar channels.

4.2.2 Soil Selection

LNG tanks, cold boxes, piping and supports, and other cryogenic equipment shall be properly sited, designed and constructed so that no damage from freezing or heaving of the soil will develop. The soil shall be selected, prepared, and protected in accordance with the requirements of the agency having jurisdiction. (Department of Ports and Terminals or Department of Buildings.)

4.2.3 Protection of Site

Plant sites shall be protected from the forces of nature as flooding by rains, high tides, or soil erosion by grading, draining and dikes. Grass, weeds, trees, or undergrowth shall be cleared within 25 feet of any piping, container, or process equipment.

4. PLANT SITE (CONTINUED)

4.3 FACILITY DESCRIPTION

A complete description of the facility shall be filed with the site plan, indicating LNG tanks and sizes, method of liquefaction and vaporization, other methods of acquiring LNG, and fire extinguishing systems. Also included shall be a detailed analysis of the product to be stored.

4.4 ROADS

At least two all-weather roads shall be provided at least 20 feet in width providing access to all areas of the facility. The roads shall be designed in accordance with the specifications of the American Association of State Highway Officials for a uniformly distributed load of 600 pounds per square foot or for the maximum vehicular wheel load that could be imposed thereon, whichever develops the greater stresses. Such design shall take into consideration the weight, height, and turning radius of the heaviest vehicles of the Fire Department which may have occasion to use the roads. Current specifications of such vehicles shall be obtained from the Fire Department. Equipment shall be provided to maintain the roads free of snow and ice accumulations and shall at all times be maintained in serviceable condition. Entry gates at least as wide as the road shall be located remote from each other to provide alternate means of access to the plant.

4.5 FENCES

A protective fence of incombustible material shall be erected at the property line, at least eight feet in height, having locked gates openable only to authorized persons on proper identification.

5. TANK SITE - DESIGN, GENERAL

a. The maximum height from the ground level to the top of the berm shall be 60 ft. and the minimum ratio of the diameter of the container to maximum liquid level shall be 3:1 (See Fig. 2).

b. LNG stored in tanks over 2500 gal. shall be protected from spillage by quadruple containment, i.e., a primary cryogenic container, a secondary cryogenic container, a concrete or earth berm which shall serve both as a tertiary container and primary impounding area, and lastly an outer dike or impounding area which shall constitute the secondary impounding area.

c. Tanks over 2500 gallon capacity to 100,000 gallons shall be enclosed in a berm of compacted earth suitably protected against soil erosion or a reinforced concrete berm. The outer shell shall be adequately protected against corrosion.

d. Tanks over 100,000 gallon capacity shall be enclosed in reinforced concrete berm designed to withstand (without damage to the primary container) the impact of the heaviest aircraft which can operate to or from any airport within a radius of ten miles at a speed of 200 knots. The effectiveness of the berm in providing such protection shall be proven by a Finite Element Analysis and Block Analysis or other acceptable method.

6. IMPOUNDING AREAS, BERMS, DIKES

Every LNG container shall be located within both primary and secondary impounding areas or dikes, except that tanks with capacity of not over 2500 gallons need only a primary impounding area or dike.

6.1 IMPOUNDING AREAS

6.1.1 Impounding Area

The impounding area formed by dikes or natural topography shall slope away from the tank to a basin provided for minor spills and shall further slope away from waterways or property lines. Cryogenically suitable approved pumps manually controlled and piping on incombustible and cryogenically suitable supports shall be used to return such spills to the tank.

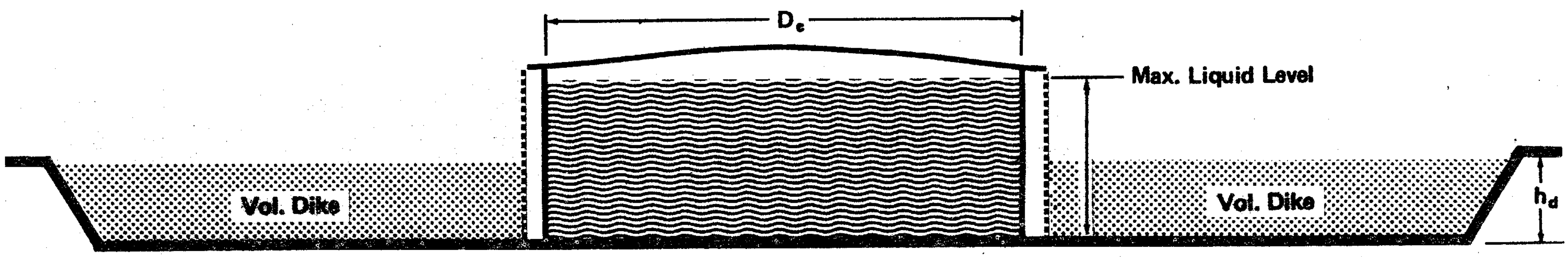
6.1.2 Impounding Area Construction

Impounding areas shall not contain underground channels, drains, conduits, or sewers. Storm water to be pumped over the dikes by means of fixed piping and manually controlled.

6.2 IMPOUNDING AREAS, NOT BERMED

6.2.1 Capacity

The minimum capacity of the area shall be 250% of the maximum liquid capacity of the container, LNG piping, and processing equipment for which the area is provided.



$$\frac{D_c}{\text{Max. Liquid Level}} \quad \frac{3.0}{1} \text{ (Min.)}$$

$$\frac{\text{Max Liquid Level}}{h_d} \quad \frac{2.0}{1} \text{ (Max.)}$$

$$\frac{\text{Volume Dike}}{\text{Volume Container}} \quad \frac{2.5}{1} \text{ (Min.)}$$

RATIO OF DIKE HEIGHT TO LIQUID LEVEL

Figure 2

6.2 IMPOUNDING AREAS, NOT BERMED (Continued)

6.2.2 Container Restrictions

Not more than one container shall be installed in a single dike and the maximum ratio of highest liquid level in the container to the height of the dike at 250% level shall be 2:1 (See Figure 2).

6.3 SITING OF PRIMARY IMPOUNDING AREAS FOR CONTAINERS NOT BERMED

Siting of containers shall be in accordance with Figure 1 or with the following formula: $d_1 = 2\sqrt{A}$ (whichever is greater) where d_1 is the distance in feet from the nearest edge of impounded liquid in the primary impounding area to process equipment, vaporizers, service buildings, process and fire control houses, transfer facilities, ignition sources or to the property line which may be built upon or to a navigable waterway, but the minimum distance to the near edge of such waterway or property line shall be 200 ft, and A = surface areas of impounded liquid.

6.4 SITING OF PRIMARY IMPOUNDING AREAS FOR BERMED TANKS

In the case of a bermed tank, siting shall be in accordance with Figure 1 or the following formula: $d_2 = 1.25\sqrt{A}$ (Whichever is greater). A = the cross-sectional area of the inner diameter of the berm, d_2 = distance in feet from the nearest edge of liquid in the primary impounding area to process equipment, service buildings, vaporizers, ignition sources, process and fire control houses and to other LNG containers or to a transfer facility.

6.4 SITING OF PRIMARY IMPOUNDING AREAS FOR BERMED TANKS (Continued)

Notwithstanding the foregoing, the edge of any impounded LNG shall not be closer than 1000' to any critical occupancy such as a school, hospital, place of assembly, bridge, or tunnel.

6.5 BERMS

Berms of reinforced concrete shall be at least ten feet thick, liquid tight, and strong enough to meet the requirement of 5.d. Berms of compacted earth shall be at least ten feet wide at the top and have a slope of 1:1-1/2. Two steel or concrete access stairways from the base to the top of the berm shall be erected diametrically opposite each other.

6.6 DIKES

a. Dikes shall be constructed of compacted earth or concrete capable of withstanding thermal shock through a temperature range of -260°F to 1800°F and capable of withstanding full hydraulic head and hydraulic surge.

b. Dikes shall be liquid tight without openings for pipes. Access roads and ramps for construction, maintenance, and fire protection vehicles are required to pass over the top of the dikes.

c. Secondary or backup dikes shall be provided for each tank over 2500 gallon capacity.

6.7 SURROUNDING AREAS

a. No sewers, underground ducts, or drains will be permitted within 500 feet of the LNG storage tank, or 50 feet of any impounding area.

6.7 SURROUNDING AREAS (Continued)

b. Drainage shall be accomplished by grading, normal evaporation, or by non-automatic means to a safe location. Where impounding areas are to be drained, all drainage piping shall pass over the top of the dike.

c. The following areas shall be graded and drained in a manner that will minimize the possibility of endangering personnel, structures, or equipment, or adjoining property through accidental spills or leaks.

1. Process areas
2. Vaporization areas
3. In-plant LNG, flammable liquid, and flammable refrigerant transfer areas.
4. Areas surrounding flammable refrigerant and flammable liquid storage tanks.

7. SPACING OF EQUIPMENT AND STRUCTURES

Minimum clearances shall be maintained for equipment and structures as noted in this section. All equipment and structures referred to in this section shall conform to the minimum clearances as presented in Figure 1.

7.1 VAPORIZERS

a. Vaporizers shall be located at least 100 feet from process equipment, boil-off compressors, flare stacks, property lines or navigable waters, flammable storage of 2500 gallons or less, and loading or unloading connections other than marine transfer facilities; at least 150 feet from any impounding area; at least 200 feet from service buildings, process control houses or fire protection control facilities; and at least 250 feet from marine transfer facilities, critical occupancy or flammable storage over 2500 gallons.

b. Vaporizers and their primary heat sources shall be located at least 100 feet from any source of ignition.

c. No vaporizer shall be located in an enclosed structure or building.

7.2 MULTIPLE VAPORIZERS

a. Clearance in multiple heated vaporizer installations shall be as recommended by the manufacturer, but not less than five feet.

7.2 MULTIPLE VAPORIZERS (Continued)

b. In multiple vaporizer installations, an adjacent vaporizer or primary heat source shall not be considered to be a source of ignition.

c. Process heaters or other units of fired equipment are not considered to be sources of ignition with respect to vaporizer siting provided they are interlocked so they cannot operate when a vaporizer is operating or when the piping system serving the vaporizer is either cooled down or in the process of cooling down.

7.3 PROCESS EQUIPMENT

Process equipment containing LNG, refrigerants, flammable liquids or gases shall be located at least 100 feet from sources of ignition, property line which may be built on, control rooms, offices, shops, or other occupied structures; at least 200 feet from fire protection control center; and at least 250 feet from marine transfer facilities or critical occupancy buildings, except that control rooms may be located in a building housing flammable gas compressors if construction complies with Sec. 8.2.

7.4 FIRED EOUIPMENT AND SOURCES OF IGNITION

Fired equipment (other than vaporizers) or other sources of ignition shall be located at least 250 feet from any impounding area, container, transfer facility, fire pump house and control, process control house, or critical occupancy; and at least 100 feet from

7.4 FIRED EQUIPMENT AND SOURCES OF IGNITION (Continued)

process equipment, vaporizers, service buildings, property line which may be built on, and boil-off compressors, except as provided in Section 7.2.c.

7.5 LOADING AND UNLOADING FACILITY

a. A pier or dock for pipeline transfer of LNG shall be located so that any tanker or barge moored thereto for loading, unloading, or containing gas shall be located at least 1000 feet from any bridge over a navigable waterway or critical occupancy; at least 250 feet from LNG storage containers, impounding areas, process equipment, process control houses, vaporizers, flare stacks or ignition sources; at least 200 feet from fire pump houses, fire protection control facilities or boil-off compressors; and at least 100 feet from service buildings, property line, or any structure intended for human occupancy for vessels having a capacity up to 30,000 barrels of LNG; 200 feet for vessels having a capacity of 50,000 barrels except for plant structures essential to transfer operations.

b. LNG and flammable liquid loading and unloading connections other than marine shall be at least 250 feet from sources of ignition, except as provided in Section 7.1.a, process areas, control buildings, and storage containers; and 200 feet from other occupied buildings. This does not apply to structures or equipment directly associated with the transfer operation.

7. SPACING OF EQUIPMENT AND STRUCTURES (CONTINUED)

7.6 LNG STORAGE CONTAINERS

LNG storage containers shall be sited in accordance with Figure 1, except as may be modified under Section 4.1.

LNG storage containers shall be located at least 500 feet from process control houses, fire pump houses, and fire protection control facilities; at least 250 feet or 1-1/2 tank diameters, whichever is greater, from another LNG container, process equipment, service building, or property line.

7.7 LNG IMPOUNDING AREAS

LNG primary impounding areas shall be located in accordance with Figure 1 or distances derived from Sections 6.3 or 6.4, whichever is greater. All impounding areas shall be located at least 1000 ft. from any critical occupancy; 500 feet from fire pump house or fire protection control facilities; 250 feet from any process control house, service building, marine transfer facility, flare stack or ignition source; 200 feet from any property line or navigable water; 150 feet from process equipment or vaporizer; and 50 feet from any sewers, underground ducts or drains.

7.8 BOIL-OFF COMPRESSORS

Boil-off compressors shall be located at least 200 feet from marine transfer facilities and at least 100 feet from storage tanks, vaporizers, process control houses, fire pump house, service building, critical occupancy, property lines, or navigable waters, or to flare stacks or ignition sources.

7. SPACING OF EQUIPMENT AND STRUCTURES (CONTINUED)

7.9 PROCESS CONTROL HOUSES

Process control houses shall be located at least 500 feet from LNG containers; 250 feet from any impounding area, marine transfer facility, flare stack or ignition source; 200 feet from any vaporizer; 150 feet from critical occupancy; and 100 feet from service buildings, boil-off compressors or process equipment.

7.10 FIRE PROTECTION

Fire pump house and fire protection control facilities shall be located at least 500 feet from LNG containers; 250 feet from any impounding area, marine transfer facility, flare stack or ignition source; 200 feet from any vaporizer;and 100 feet from critical occupancy or service buildings.

8. BUILDING AND STRUCTURES

8.1 CONSTRUCTION

8.1.1 General

All buildings and structures shall be of non-combustible construction classified as Group I in the Administrative Code, Sec. C26.314.1. Buildings or structural enclosures in which LNG, flammable refrigerants or flammable gases are handled, stored or used shall be of lightweight non-combustible construction Class I-E with non-load bearing walls, and explosion venting conforming to the requirements of NFPA STD 68-1954 and the Department of Buildings as specified in the Administrative Code, Sec. C26.701.2.

8.1.2 Prohibited Areas

All such buildings shall be built on grade without below grade areas.

8.2 ROOMS CONTAINING FLAMMABLES OR CRYOGENIC FLUIDS

8.2.1 General

If rooms containing cryogenic or flammable fluids are located within or attached to building in which such fluids are not handled, i.e., control rooms, shops, etc., there will be permitted one common wall which shall be Class I-A construction, or four-hour fire resistance rating without openings, and designed to withstand an explosive force of at least 100 psf, and shall be gas-tight.

8.2.2 Explosion Protection

Such rooms shall be further protected against explosion by installation of the following equipment:

a. Exhaust System:

A continuously operating high and low level mechanical exhaust system capable of venting at the rate of at least 1 cfm of air per square foot of floor area. This shall be a dual rate system which will double its exhaust capability on detection of a flammable gas or vapor of 10% Lower Explosive Limit (LEL), such detector shall then initiate the Emergency Shut Down (ESD) at 25% LEL.

The exhaust system shall extend to all areas, pits or floor depressions.

b. Ventilators;

A system of open ridge ventilators shall be provided.

9. PROCESS SYSTEMS

9.1 PROCESS EQUIPMENT LOCATION

Processing equipment containing LNG, flammable refrigerants or gases shall be located outdoors insofar as possible. When necessary to locate such systems indoors, buildings shall comply with Section 8.

9.2 PUMPS AND COMPRESSORS

9.2.1 Materials of Construction

Pumps and compressors shall be constructed of materials suitable for the conditions of temperature, pressure and use which they are expected to encounter and shall be approved and certified to the Fire Department as hereinafter provided.

9.2.2 Valves

Every pump and compressor shall be valved so that it can be isolated for maintenance. When installed in parallel, each discharge line shall have a check valve, in addition.

9.2.3 Pressure Relief

Pump and compressors shall be provided with a pressure relieving device on the discharge to limit the pressure to the maximum safe working pressure of the casing and downstream equipment.

9.2.4 Vent and Relief Valves

Each pump shall be provided with an adequate vent and relief valve which will prevent overpressuring the pump casing during the maximum possible rate of cooldown.

9.2 PUMPS AND COMPRESSORS (Continued)

9.2.5 Pump Installation

Pumps used for transfer of liquids at temperatures below -20°F shall be provided with suitable means of precooling to reduce the effect of thermal shock.

9.2.6 Foundation and Sumps

The foundations and sumps for cryogenic pumps shall be of incombustible construction, designed and constructed to prevent frost heaving.

9.3 FLAMMABLE REFRIGERANT AND LIQUID STORAGE

Installation of storage tanks for flammable refrigerants and liquids shall comply with the requirements of Chapter 19 of the Administrative Code.

9.4 PROCESS EQUIPMENT

9.4.1 Siting

Process equipment shall be sited in accordance with the distance requirements of Section 7.

9.4.2 Boilers

Boilers shall be designed, fabricated, approved and certified in accordance with the requirements of the Administrative Building Code.

9.4.3 Heat Exchangers

Shell and tube heat exchangers shall be designed, fabricated, tested, inspected, approved and certified by the

9.4.3 Heat Exchangers (Continued)

manufacturer in accordance with the requirements of the Tubular Exchanger Mfrs. Assoc. (TEMA) 1968 edition. Certification certificates shall be filed with the Fire Department.

The shells and internals of all exchangers shall be pressure tested, inspected and stamped in accordance with Sec. VIII, Div. 1, of the ASME Boiler and Pressure Vessel Code, 1971 edition, when such components fall within the jurisdiction of this code. A copy of the ASME certification of test and inspection shall be filed with the Fire Department.

9.4.4 Engine and Turbines

Installation of internal combustion engines or gas turbines shall comply with the requirements of Chapter 26 of the Administrative Code and NFPA 37, 1970 (Installation and Use of Stationary Combustion Engines and Gas Turbines).

9.4.5 Boiloff and Flash Gas Systems

a. A boiloff and flash gas handling system separate from container relief valves shall be installed for the safe disposal of vapors generated in the process equipment and LNG containers.

b. LNG containers shall have their boiloff and flash gases discharge safely to atmosphere or closed system, designed to prevent in-breathing of air.

9.4.5 <u>Boiloff and Flash Gas Systems</u> (Continued)

c. Provision may be made to introduce natural gas or nitrogen into the containers in the event a vacuum is experienced if the natural gas so introduced will not create a flammable mixture in the container.

9.5 DEPRESSURIZING EQUIPMENT

9.5.1 Emergency Depressurization

Provision shall be made for depressurizing equipment containing gases and liquids in case of fire, failure of the equipment or similar emergency. Emergency controls for depressurization shall be readily accessible and suitably designated.

9.5.2 Gas and Liquid Disposal

Gases in the processing equipment shall be vented to the flare stack and LNG shall be relieved to a dump tank which shall be vented to the flare stack. The liquid dump tank shall be of cryogenically suited material large enough to contain all LNG in the processing equipment. Construction shall be in accordance with Chapter 19, Article 17 of the Administrative Code. The tank shall be protected against fire by being buried or enclosed in 4-hour rated material, unless it can be proven to the satisfaction of the Fire Department that the anticipated amount of LNG can be quickly vaporized and relieved to the flare stack, and no LNG will accumulate.

9.5 DEPRESSURIZING EQUIPMENT (Continued)

9.5.3 Compression Equipment Vents

Compression equipment handling flammable gases shall be provided with adequate vents piped to relieve to the flare line.

9.6 COLD BOX CONSTRUCTION

The cold box structure and equipment shall be constructed of incombustible material. Cold boxes shall be considered as flammable gas containers for the purpose of purging and shall be subject to the regulations relative thereto as contained in this regulation. If a flammable gas-air mixture is detected in the cold box, inert purge gas shall be introduced until a flammable mixture no longer exists.

9.7 AIR INJECTION

Air shall not be injected or introduced into the plant inlet gas stream.

9.8 PROCESS REPORT

A process report shall be filed with the Fire Department, for review; such report shall contain the following:

a. Process information on incoming feedgas treatment, refrigeration, liquefaction, vaporization, deriming and odorization.

b. Basis for approval of all equipment used with reference to the standards of construction, e.g., ASME, ANSI, Chapter 19, Administrative Code and Chapter 26, Administrative Code.

c. All other items specified in Section 22.5.2.

10. STATIONARY LNG CONTAINERS, GENERAL

10.1 PRIMARY CONTAINER

10.1.1 Suitability for Service

The primary container for LNG shall be cryogenically suited material. All materials in direct contact with LNG shall be physically, chemically and thermally compatible with LNG. NFPA STD 59A-1972, Sec. 423, shall be used as a guide in such determination.

Storage containers for LNG shall be designed for the minimum temperature of LNG to be stored at atmospheric pressure. Container foundations shall be capable of withstanding contact with LNG so as not to threaten structural integrity.

10.1.2 Structural Design

Structural design shall be predicated on the density of the product to be stored but not less than 29.3 pounds per cu. ft. and suitable allowance made for the requirements of hydropneumatic testing found in Section 20 of these regulations. No product with a density greater than that for which the container has been designed shall be stored until permission has been obtained from the Fire Department based on supporting data and calculations and approvals granted by the Department of Buildings and/or Department of Ports and Terminals. If deemed applicable by the Department of Buildings and/or Department of Ports and Terminals, seismic loads shall be considered in the design.

10.1 PRIMARY CONTAINER (Continued)

10.1.3 Insulation

Insulation in both non-load bearing and load-bearing areas shall be incombustible. Exposed insulation shall contain, or be inherently a vapor barrier, be water free and resist dislodgment by fire hose streams. An outer shell used to contain loose insulation shall be constructed of steel or concrete. Exposed weather-proofing shall be incombustible. No combustible or flammable adhesives for insulations shall be used.

10.2 INSPECTIONS, GENERAL

Prior to initial operation, containers shall be inspected to assure compliance with the engineering design and with the material, fabrication, assembly and test procedures of this regulation. These inspections and tests shall be made by the operator and his designated employee in the presence of and witnessed by representatives of the Fire Department, Department of Ports and Terminals, Department of Buildings or other agencies having jurisdiction.

Testing of LNG containers shall be conducted in accordance with the requirements contained in Section 20 of this regulation.

10.3 MAXIMUM PRESSURE

The operator shall specify the maximum allowable working pressure which shall include a satisfactory margin above the operating pressure, and the maximum allowable vacuum.

11. METAL CONTAINERS

11.1 GENERAL

Metal containers shall be 9% nickel steel alloy, stainless steel, aluminum, or other metal authorized under Section VIII, Division 1, ASME Boiler and Pressure Vessel Code, 1971 edition, for use at -260°F. The use of a non-rigid container or liner is prohibited.

Metallic tanks shall be fabricated in accordance with the requirements of API STD 620, Appendix Q, July 1973 or equivalent, except as herein modified.

11.2 FOUNDATIONS

Above ground LNG containers shall be supported on suitable concrete foundations designed to comply with Chapter 26 of the Administrative Code and API Standard 620, Appendix Q, July 1973, for a container to be tested with water to the top of the shell. The design shall be done by an engineer qualified in this specialty and reviewed and filed with the Department of Ports and Terminals or Department of Building by a professional engineer licensed in the State of New York, and a copy of the approved plan filed with the Fire Department.

11.3 CONTAINERS DESIGNED FOR 15 PSIG OR LESS

Welded primary and secondary containers designed for not more than 15 psig shall comply with API Standard 620, Appendix Q, July 1973 except as herein modified. All welds shall be made by welders licensed by the Department of Buildings under Art. 3, Title B, Chapter 26 of the Administrative Code. All butt welds

11.3 CONTAINERS DESIGNED FOR 15 PSIG OR LESS (Continued)

shall be 100% radiographed (horizontal and vertical). Lap welds shall be subjected to a vacuum box test as per API 620, July 1973. A solution vacuum box test shall also be made of the inner and outer tank bottom corner welds, inner tank reinforcing plate to shell welds, reinforcing plate to neck welds and neck-to-shell welds.

Magnetic particle or other acceptable methods shall be permitted where other methods are impractical, subject to the approval of the Fire Department and Department of Buildings and/or Department of Ports and Terminals. All fluxes used in welding shall be thoroughly removed.

11.4 CONTAINERS DESIGNED FOR MORE THAN 15 PSIG

11.4.1 General

Containers shall be double-walled with inner container holding the LNG surrounded by insulation contained by the outer jacket. The insulation shall be evacuated or purged.

11.4.2 Inner Container

The inner container shall be fabricated of material authorized by the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, 1971 edition, for cryogenic liquids at -260°F. The inner container shall be of welded construction conforming to the ASME Boiler and

11.4.2 Inner Container (Continued)

Pressure Vessel Code, Section VIII, Division 1, 1971 edition, and designed for a pressure not less than total of working pressure, LNG hydrostatic head and vacuum if any. The inner container shall be supported concentrically within the jacket by a system capable of sustaining the maximum loads.

11.4.3 Outer Jacket

The outer jacket shall be of welded steel construction in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, 1971 edition. In the case of positive pressure purge, the jacket shall be designed to be capable of structurally supporting the inner tank and insulation and maximum positive pressure of the purge gas; in the case of vacuum use the jacket shall be designed to resist an external pressure at not less than 15 psig.

The jacket shall be equipped with a relief device functioning at a pressure not greater than the internal design pressure of the jacket, the external design pressure of the inner tank or 25 psi, whichever is less.

11.4.4 Thermal Barriers

Thermal barriers shall be provided between cold lines and the jacket. Only incombustible insulation compatible

11.4.4 Thermal Barriers (Continued)

with LNG and natural gas shall be used between the inner container and jacket. Such insulation shall be water free, capable of withstanding thermal cycling between -260°F and 1800°F without decomposition, embrittlement, settling or deterioration, and chemically non-reactive with LNG or natural gas. The inner container shall be designed to withstand without collapsing, the external pressure of the insulation and purge gas.

11.4.5 Support Systems

Support systems shall be designed with due consideration to expansion and contraction of the inner container and all thermal stresses created. Saddles and legs shall be designed to withstand the effects of LNG fires, spills, wind loads, shipping loads, erection loads and seismic loads, and accidents attributable to motor vehicles.

11.5 INTERNAL LINES

Internal lines between the inner container and the jacket shall be designed for the pressure rating of the inner container and allowance made for thermal stresses created. No bellows shall be permitted in the annular space. All such internal lines shall be of materials acceptable under the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, 1971 edition, for cryogenic liquid at -260°F.

12. CONCRETE CONTAINERS

12.1 PRESTRESSED CONCRETE CONTAINERS

This section applies to the design and construction of prestressed concrete containers for any operating pressure, whether externally or internally insulated and for prestressed concrete walls or berms surrounding any container.

Non-metallic tanks shall be prefabricated or poured in place reinforced concrete. After the concrete has attained 90% of 28-day strength the tank shall be post-stressed with steel wires, both vertically and circumferentially for tank walls and floors to assure that concrete will remain in compression during all phases of tank operation. Except as modified in these regulations, construction, materials, and tests shall be in accord with applicable ACI, ASTM, and API specifications enumerated in Sections 423 and 424 of Std. 59A-1972 of the NFPA code.

The Department of Buildings or Department of Ports and Terminals shall provide surveillance and inspection to insure compliance with the applicable requirements and shall require such tests and engineering data as it deems necessary and appropriate.

12.1.1 Foundations

Concrete LNG containers shall be supported on foundations of concrete, steel or combination which shall have been designed and constructed in accordance with recognized structural engineering practices to ensure a stable

12.1.1 Foundations (Continued)

foundation. Anchorage shall be provided to counteract flotation forces unless it can be proven to the satisfaction of the Department of Buildings and/or Department of Ports and Terminals that such is not necessary. All exposed steel shall be fireproofed with concrete or insulation resistant to dislodgement by hose streams, and shall have a minimum fire-resistant rating of 4 hours. The foundations shall be designed to support the concrete tank filled with water to the top of the shell during tests.

The design shall be done by an engineer qualified in this specialty and reviewed and filed with the Department of Ports and Terminals or Department of Buildings by a professional engineer licensed in the State of New York, and a copy of the approved plan filed with the Fire Department.

12.1.2 Container Construction

a. Design and construction of the container shall comply with applicable provisions of Chapter 26, Administrative Code and/or recognized standards accepted by the Department of Buildings and/or Department of Ports and Terminals to provide maximum safety. No construction on any container shall begin until such agency shall have certified to

12.1.2 Container Construction (Continued)

the Fire Department that the container, as designed, does meet the required standards and is satisfactory for the storage of LNG, has provided the Fire Department with such data concerning the container which the Fire Department deems necessary, and after the Fire Department has indicated, in return, its acceptance of the design. Materials subject to LNG temperature shall be selected, specified, tested and utilized in accordance with the requirements of the Fire Department and the Department of Buildings and/or Department of Ports and Terminals based on recognized engineering standards. The tank shall be designed to withstand testing by filling with water to the top of the shell.

b. The use of alternative materials of construction may be approved by the Department of Buildings and/or Department of Ports and Terminals provided that after due investigation such agency is satisfied that such substitutions provide, at least, an equivalent degree of safety and further provided that the Fire Department concurs in such substitution.

c. Roof structures and suspended ceilings shall be of materials suitable for cryogenic temperatures and so constructed as to prevent total roof collapse

12.1.2 Container Construction (Continued)

in the event of internal fire. Roof guides shall be incorporated into the structure to minimize the possibility of the roof falling into the tank in the event of pressure surge within the container.

d. The seal between wall and floor shall be of a type acceptable to the Fire Department and the Department of Ports and Terminals and/or Department of Buildings. It shall not be a corrugated type expansion seal.

13. CONTAINER PURGING

13.1 PURGING

Purging shall be conducted by experienced and qualified personnel under the direction of an experienced engineer competent in this specialty, who shall prepare a written procedure for review and acceptance by the Fire Department prior to the start of purging.

Responsibility and authority for the purging operations should be vested in a person who is familiar with the properties and nature of the materials involved and the construction and function of the equipment to be purged. He should be capable of deciding how the purging should be done and of judging whether it is proceeding satisfactorily and when it is properly completed. He should be able to detect any hazards and to decide how best to overcome any difficulties that might arise. He should plan and discuss the schedule of the entire operation with operating, maintenance, engineering, testing and safety personnel involved.

13.2 CONTAINER INTO SERVICE

Prior to placing an LNG container into service the air must be displaced by an inert gas such as nitrogen in an acceptable manner so that at no time will there be a flammable mixture in the container.

13.3 CONTAINER OUT OF SERVICE

Prior to taking a container out of service the natural gas shall be purged with an inert gas such as nitrogen in a safe

13.3 CONTAINER OUT OF SERVICE (Continued)

manner. All tank interior maintenance and repairs shall be performed in an atmosphere of inert gas.

13.4 PURGING OPERATION

a. During purging operation the interior of the container shall be continuously monitored for the presence of oxygen and flammable gas.

b. Good organization, planning and preparation with full agreement of all concerned are essential for a successful purging project. The following factors must be decided upon:

   1. Equipment to be purged and how it should be separated.
   2. Inerts to be used, how obtainable, and how introduced and vented.
   3. Method for testing completeness of the purging and end point to be attained.
   4. Selection and assignment of a responsible supervisor and operating personnel.
   5. Preparation of a written "procedure," detailing the sequence of all operations related to the purging, including the time of performance and estimated duration.

c. Selection of the time for performing the purging may be affected by many factors not directly related to the operation itself, such as: demands and loads, available of personnel to perform the repair work or task for which the purging is undertaken, and weather conditions.

It is desirable to start the purge operation at a time that will permit completion of purging, the introduction and removal of the inerts and the return to service of the system during daylight hours.

d. When more than one unit or piece of equipment is involved, the purging should be broken down into several successive operations, with their sequence definitely decided upon and their timing clearly calculated and scheduled. Each successive part of a large scale operation may well be considered a separate purging.

It is important to set down the decisions reached in a written "procedure" which is definite as to consecutive steps. For instance, that no valve is left open when it should be closed or vice versa.

e. After review and acceptance of the written procedure by the Fire Department, the purging supervisor may proceed with the selection of those required to assist in the operation. All should then be instructed together in the work to be done. Each man should understand what he is to do and its importance in relation to the work others must perform.

f. Those selected to aid in the purging operation should have definite responsibilities. For example, one man may be made responsible for the production and continuity of

13.4 PURGING OPERATIONS (Continued)

supply of inerts, a second, who has analytical and chemical testing training, responsible for the testing of the contents in or escaping from the purged chambers. These men should concentrate all their attention on their indicated duties and should not be expected to perform any other tasks. As many other men as deemed necessary should be assigned for the general purging operations.

14. COOLDOWN PROCEDURE

a. Cooling down shall be limited to a rate and distribution pattern which will not cause allowable thermal stresses in the container and LNG piping to be exceeded.

b. Cooldown shall be conducted by qualified and experienced personnel under the supervision of an engineer competent in this procedure.

c. The container, associated piping and joints shall be under continuous surveillance to detect any failures or leaks.

15. PRESSURE AND VACUUM CONTROL

15.1 GENERAL

LNG containers shall be provided with means of maintaining pressure and vacuum within design limits by admitting or discharging natural gas as needed. The means provided for the admission and release of gas as required in this section shall be acceptable to the Fire Department.

15.2 SIZING

Sizing such pressure control devices shall include consideration of, (but not be limited to), the following factors:

a. For Pressure -

1. Loss of refrigeration.
2. Failure of a control device or other deviation from normal operation.
3. Vapor displacement and flash vaporization including thermal rollover during and subsequent to filling.
4. Drop in barometric pressure.
5. Exposure to fire or radiation from fire.

b. For Vacuum -

1. Withdrawal of liquid at maximum rate.
2. Withdrawal of vapor at maximum compressor suction rate.
3. Rise in barometric pressure.
4. Reduction in vapor pressure resulting from the introduction of sub-cooled LNG into the vapor space.

15. <u>PRESSURE AND VACUUM CONTROL</u> (CONTINUED)

15.3 VENTS

In addition to the pressure control means required under the foregoing, LNG containers shall be provided with dual sets of direct acting pressure and vacuum vents communicating with the atmosphere. Each sized for total relief. Fire exposure must be considered in the sizing of pressure relief vents.

15.4 VENT CALCULATIONS

Copies of venting and relief valve calculations for LNG storage tanks and equipment shall be furnished to the Fire Department.

16. VAPORIZATION

16.1 GENERAL

There are various classifications of vaporizers. This section describes these classifications and their associated equipment.

16.1.1 Heated Vaporizers

Heated vaporizers are those vaporizers which derive their heat from the combustion of fuel, electric power, or waste heat, and can be of direct fired, indirect fired, or remote fired.

16.1.2 Ambient Vaporizers

Ambient vaporizers are those vaporizers deriving their heat from natural sources.

16.1.3 Process Vaporizers

Process vaporizers are those vaporizers which derive their heat from another thermodynamic or chemical process or in such a fashion as to conserve or utilize the refrigeration from the LNG.

16.2 PROHIBITED VAPORIZERS

Flammable heat transporting mediums are prohibited for any type of vaporizer, except that natural gas may be used in derime heaters.

16.3 DESIGN AND MATERIALS OF CONSTRUCTION

ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, 1971 edition shall govern the design, fabrication and inspection

16.3 DESIGN AND MATERIALS OF CONSTRUCTION (Continued)

of vaporizers. Materials used shall be suitable for the temperatures and pressures to which they may be exposed.

16.4 VAPORIZER AND VAPORIZER PIPING VALVES

16.4.1 Automatic equipment acceptable to the Fire Department shall be provided to prevent discharge of LNG or gas into a distribution system at a temperature above or below the design temperature of the sendout system.

16.4.2 Block Valves

Manifolded vaporizers shall have both inlet and discharge block valves at each vaporizer.

16.4.3 Discharge and Relief Valves Materials and Construction

The discharge valve of each vaporizer and piping components and relief valves upstream of that valve shall be suitable for operation at LNG temperatures.

16.4.4 Inlet Valves

In order to prevent a leak of LNG into idle vaporizers there shall be two inlet valves and a safe means of disposal of gas which may be trapped between them shall be provided.

16.4.5 Heat Source Shut-off Valves

Each heated vaporizer shall be provided with heat source shut-off valves at the vaporizer and at a point at least fifty feet distant.

16.4 VAPORIZER AND VAPORIZER PIPING VALVES (Continued)

16.4.6 Vaporizer Shut-off Valve

The LNG line to each vaporizer shall be provided with a shut-off valve at least fifty feet distant from the vaporizer operable from a remote point and manually at its installed location.

16.4.7 Derime Heater Shut-off Valves

If natural gas is used with a derime heater, shut-off valves shall be provided in both feed and discharge lines, located at least fifty feet from the heater.

16.4.8 Relief Devices

a. Each vaporizer and/or heater shall be provided with a safety relief valve providing an effective rate of discharge. Relief valve calculations shall be submitted to the Fire Department for review and acceptance and shall include allowance for pressures developed due to fire exposure.

b. Relief valves on heated vaporizers shall be located so that they are not subjected to normal operating temperatures in excess of their design temperature.

16.5 SAFETY CONTROLS

In order to assure safe operation, heated vaporizers shall be proved with fully automatic, fail-safe controls, electrically

16.5 SAFETY CONTROLS (Continued)

classified by New York City Electrical Code to operate in hazardous atmospheres, to accomplish the following:

a. Prepurge for 1-3/4 minutes with air or inert gas heat exchangers of combustible gases. Purge timer, solenoid control pilot and fuel gas valves and ignition time limit switch to be provided.

b. Startup on low fire start by pilot only with burners, then lit by pilot as they open.

c. Monitor for process temperature, pressure and/or flow with shutdown if any parameter is exceeded.

d. Monitor flue gases with flue gas analyzer to detect gas or unburned fuel, also to report surplus oxygen.

e. Shutdown on insufficient air. Combustion air blower and combustion air pressure switch to be provided for combustion air blower and fuel gas and combustion air proportional control valve to be provided.

f. Shutdown on electrical malfunction.

g. Shutdown on flame failure of pilot or burner.

h. Shutdown on high stack temperature (no restart possible until the temperature returns to normal operating temperature).

16.5 SAFETY CONTROLS (Continued)

i. Vary burner gas and air input with LNG flow rate to maintain output process temperature within prescribed limits. (Automatic proportional temperature control).

j. A tamper control with supervisory signal to be provided in the electrical panel box which will alert manager of the plant in event the door is opened for any reason. (This is to guard against by-passing of controls by any operator).

k. Combustion air blower to be designed with limited capacity to prevent over-firing of unit.

17. PIPING

17.1 DESIGN AND MATERIALS - GENERAL

a. Design

The design and fabrication of piping systems shall comply with American National Standard (ANSI) B31.3 "Petroleum Refinery Piping," except as modified by this section.

b. Materials

All materials, including gaskets and thread compounds shall be suitable for the temperatures to which they may be exposed, including fire. A materials list shall be prepared and submitted to the Fire Department for review and acceptance.

17.2 SEAMLESS PIPE

Seamless pipe, only, shall be used for process and transfer piping handling LNG, flammable refrigerants, flammable liquids or gases, except that welded pipe may be used if seamless pipe is not available in the size required and if the weld and heat affected zone complies with ANSI B31.3 Subs. 323.2.2 (impact tests) and is non-destructively examined in a manner acceptable to the Fire Department. Furnace lap-welded, furnace butt-welded or spiral-welded pipe is not acceptable for flammable gas, refrigerant or LNG. All fluxes used in welding shall be thoroughly removed.

17.3 THREADED PIPE

Threaded pipe shall be at least Schedule 80, but no threaded pipe over 2" nominal pipe size shall be used and all threaded

17.3 THREADED PIPE (Continued)

joints used must be seal-welded.

17.4 THERMAL EXPANSION

Thermal expansion shall be provided for by means of piping bends, loops or offsets. Expansion joints of the bellows, slip, and ball type are prohibited for lines handling flammable liquids or gases.

17.5 PROHIBITED MATERIALS

A liquid line on a storage container, coldbox or other major item of insulated equipment external to the outer shell or jacket whose failure can release a significant quantity of flammable fluid shall not be made of aluminum, copper or copper alloy.

17.6 PROHIBITED FABRICATION

Socket welds on piping shall be prohibited except for branch connections not over 2" diameter; threaded pipe joints not seal welded, expanded, flared, compression, caulked, brazed and soldered joints are prohibited except as permitted in Section 17.7. Flange joints shall be held to a minimum. Butt welded joints shall be used wherever possible.

17.7 PIPE FITTINGS

17.7.1 <u>General</u>

a. Metals may be joined for cryogenic service by silver brazing. Silver brazing may be used on

17.7.1 General (Continued)

copper to copper joints, copper to copper alloys, and copper to stainless steel. Dissimilar metals may be joined by flanges or transition joint techniques which have been proven by test.

b. The number of threaded or flanged joints shall be held to a minimum and used only where absolutely necessary, such as material transitions, instrument connections or where required for maintenance.

c. Care shall be taken to insure the tightness of all bolted connections. Spring washers or other devices designed to compensate for the contraction and expansion of bolted connections during normal operating cycles shall be used where required.

17.7.2 Threaded Nipples

Threaded nipples shall be at least Schedule 80.

17.7.3 Malleable Iron

Malleable iron fittings are permitted only in auxiliary systems for oil, water, air, etc., and shall not be used to convey flammable refrigerants, gases, or liquids.

17.7.4 Plugs

Solid plugs or bull plugs made of at least Schedule 80 seamless pipe shall be used for threaded plugs.

17.7 PIPE FITTINGS (Continued)

17.7.5 Flanges

Flanges shall be butt welded to the piping. All flanges shall be raised face and shall be concentric serrated in conformance with Manufacturers Standardization Society of the Valve and Fitting Industry, MSS-SP-6, 1963.

17.8 GASKETS

Gaskets on piping conveying LNG, flammable refrigerants or gases shall be metal, metal jacketed or retained spiral wound.

17.9 PROHIBITED CONDITIONS

The following practices and conditions shall be prohibited.

a. Compression type couplings are not permitted.

b. Threaded pipe shall be avoided for service temperatures below -20°F. Where permitted threaded joints shall be seal welded.

c. No bends in fittings beyond those which are designed or fabricated into the fitting are permitted.

17.10 VALVES

17.10.1 General

In addition to complying with ANSI B31.3, Sec. 307, valves shall comply with ANSI B31.5 or B31.8 or API 6D if design conditions fall within their scope.

17.10 VALVES (Continued)

17.10.2 Extended Bonnet Valves

a. Extended bonnet valves with or without bellows seals shall be used for service temperatures below -50°F.

b. Extended bonnet valves shall be installed with stems positioned above the horizontal.

17.10.3 Shut-off Valves

a. Shut-off valves shall be provided on all LNG, flammable refrigerant, flammable liquid and flammable gas containers, tank and vessel connections, except those for relief valves, those for liquid level gaging devices, and those that are blanked or plugged. Shutoff valves shall be located as close as possible to the containers or vessels they protect.

b. The design and installation of an internal valve shall be such that any failure of the penetrating nozzle from outside stresses will be beyond the shut-off seats of the internal valve.

c. The number of shut-off valves shall be the minimum required for safe and efficient operation.

17.10.4 Blocking and Manual Valves

17.10.4.1 Required Automatic Blocking Valves

Automatic blocking valves of "fail safe"

17.10.4.1 Required Automatic Blocking Valves (Continued)

type shall be installed in addition to manual valves to limit and isolate leaks, and to protect the plant in case of fire or other emergency, as follows:

a. Natural gas feed line to the liquefaction system (where it enters plant).

b. Natural gas feed line to the derime heater.

c. LNG fill line from the cold box to the LNG container (at cold box).

d. LNG withdrawal lines to booster pumps from tank (at the pumps, at the tank and at the dike).

e. LNG feed line to the vaporizers (at vaporizer).

f. Natural gas line outlet from vaporizers to sendout line (at vaporizer).

g. Natural gas vapor boil-off line from tank to process area (near tank)

h. Discharge line of refrigerant compressor.

i. Additional valves for isolation shall be installed as required by the Fire Department.

17.10.4.2 Automatic Blocking Valve Operation and Activation

These valves shall be capable of manual operation and shall operate automatically on:

17.10.4.2 Automatic Blocking Valve Operation and Activation (Continued)

a. Detection of fire at tank, dike, vaporizer or process area or fire endangering the valve.

b. Indication of over-pressure of relief valve settings or under-pressure (leak or rupture).

c. Actuation of emergency shut-down system, manually, or automatically at process control house or other selected sites.

d. Manual operation of natural gas control valve.

17.10.5 <u>Safety and Relief Valves</u>

a. Safety and relief valves shall be arranged to prevent damage. No shut-off valves are permitted in a line of relief. Relief valve settings shall be sealed.

b. A thermal expansion relief valve shall be installed to prevent overpressure in any section of a liquid pipeline which can be isolated by valves. Thermal expansion relief valves shall be set to operate above the maximum normal operating pressure and less than the rated test pressure of the line it protects.

17.10.5 Safety and Relief Valves (Continued)

c. Discharge from such valves shall be directed to minimize hazard to personnel and equipment. Flammable liquids and gases shall be discharged to the plant system connected to an operating flare stack.

17.10.6 Valve Installation

Valves and other control valves shall be installed so that their operation will not be affected by icing.

17.10.7 Valve Identification

Valves shall be identified at their locations by a number and where feasible a brief statement of its function.

17.11 PIPE SUPPORTS

Supports for piping shall be capable of withstanding a two-hour fire exposure except that supports subject to exposure to cold liquid or essential to plant safety shall be capable of withstanding such exposure without excessive heat transfer which can affect piping restraints due to icing, or embrittlement of supporting steel, and to a fire of four hours duration.

17.12 PIPE IDENTIFICATION

Process, fuel, high pressure steam, fire protection and other critical piping shall be identified by color coding, painting or labeling, subject to the approval of the Fire Department.

17.13 WELDING

17.13.1 Certification of Welders

Only certified welders shall be employed and certifications of welders filed with the Fire Department. Piping welders shall be certified by their employers after qualifying under Section IX - ASME Boiler and Pressure Vessel Code 1971, or Standard for Welding Pipelines (API Std. 1104) 1968.

17.13.2 Radiographic Inspection

All welded joints shall be subjected to radiographic testing by an outside person or firm qualified to perform radiographic testing under Section IX - ASME Boiler and Pressure Vessel Code (1971) or API Standard 1104. Certifications on acceptance or rejection of each weld shall be filed with the Fire Department by such person or firm employed to do such testing.

17.13.3 Visual Inspection

All welded joints shall be subject to visual examination, over the entire O.D. and I.D. (with mirrors) by the welding inspector employed by the owner.

17.13.4 Supplementary Inspection

Supplementary examinations for soundness shall be made as required of welds on pipe and fittings conveying cryogenic liquids, high heat and high pressure flammable liquids or flammable gases, and flammable refrigerants. These shall include:

17.13.4 Supplementary Inspection (Continued)

a. Ultrasonic over entire O.D. and/or

b. Penetrant oil over entire O.D. (for non-magnetic material), and/or

c. Magnetic particle test for magnetic material

d. Welds shall be rejected for cracks and unworkmanlike welding.

17.13.5 Practices and Techniques

The following practices and techniques shall be observed:

a. Scabs, slivers, seams, laps, tears, abrasions, and mechanical marks must be removed within the minimum wall thickness.

b. When welding impact tested materials, qualified welding procedures shall be used to minimize degradation of the low temperature properties of the material.

c. When welding to thin wall pipe, techniques shall be exercised to avoid burn-through.

d. Electric arc or inert gas-shielded welding shall be used in piping for service below -20°F.

17.14 WELD IDENTIFICATION

Weld identification markings for pipe which will be subject to service temperatures below -20°F shall comply with the following:

a. Marking shall be made with a material compatible with the basic material or with a round-bottom low stress die, except that materials less than 1/4" thick shall not be die-stamped.

b. Aluminum shall be marked with chalk wax-base crayons or marking inks containing organic coloring.

17.15 TESTING OF PIPING

17.15.1 Pressure tests shall be made of all piping in accordance with Section 20.5 of these rules relating to the procedures.

17.15.2 Such tests shall be made in the presence of a representative of the Fire Department and the written results thereof promptly filed with the Fire Department.

17.15.3 Records of such tests shall include clear identification of the piping, pressure, test medium, temperature thereof, ambient temperature, duration, and shall remain a permanent record.

17.16 PURGING OF PIPING SYSTEMS

Purging of air or gas shall be done in a safe manner. ANSI B31.8, Sec. 841.285 may be used as a guide. Blow down and purge connections shall be provided to facilitate purging of process and flammable gas piping.

18. INSTRUMENTATION AND ELECTRICAL SERVICES

18.1 LIQUID LEVEL GAGING - LNG CONTAINERS

Each LNG container shall be equipped with approved liquid level gaging devices acceptable to the Fire Department.

18.1.1 High Level Alarm

Each LNG container shall be equipped with approved liquid level alarm separate from the liquid level gaging device which will sound at the control house and at the marine unloading station when the liquid level is at 95% of the maximum filling height. Such audible alarm shall not be capable of being silenced until the valves on the container fill lines from the Marine Unloading Station are closed. In addition a visible alarm shall be provided in the control board at the control house and marine station.

18.1.2 High Level Cut-off Device

A high level cut-off device in addition to the alarm shall be provided to automatically reduce the flow of LNG to the container at 95% and cut it off at 98%.

18.1.3 Try Cocks

No liquid try cocks are permitted.

18.2 LIQUID LEVEL GAGING - TANKS FOR REFRIGERANTS AND/OR FLAMMABLE PROCESS FLUIDS

Each refrigerant and/or flammable process fluid tank shall be

18.2 LIQUID LEVEL GAGING (Continued)

equipped with approved liquid level gaging devices acceptable to the Fire Department.

18.2.1 <u>High Level Alarm and Cut-off Device</u>

Each storage tank shall be equipped with a liquid level gage and a high liquid level alarm and automatic cutoff as in sub-sections 18.1.1, 18.1.2.

18.2.2 <u>Try Cocks</u>

No liquid try cocks are permitted.

18.3 PRESSURE GAGES

a. LNG containers and other pressure vessels - Each LNG container and pressure vessel shall be equipped with a pressure gage connected to the container above the maximum liquid level. The LNG container shall also be provided with a pressure recorder.

b. Liquefaction systems - Pressure gages shall be placed upstream and downstream of process equipment where trace contaminants in the feed stream may deposit, as an aid to the scheduling of deriming operations.

18.4 VACUUM GAGES

Vacuum jacketed equipment shall be provided with instruments for checking the absolute pressure in the annular space.

18. INSTRUMENTATION AND ELECTRICAL SERVICES (Continued)

18.5 TEMPERATURE INDICATORS

Temperature monitoring devices shall be provided in various locations of the LNG Plant as follows:

18.5.1 LNG Containers

Temperature monitoring devices shall be provided in LNG containers to assist in controlling temperatures when placing the container in service and for calibrating liquid level gages.

18.5.2 Vaporizers

Vaporizers shall be provided with indicators to monitor inlet temperatures of LNG, outlet temperatures of vaporized gas and heating medium fluids and stack temperatures.

18.5.3 Liquefaction Systems

Liquefaction systems shall be provided with temperature monitoring devices upstream and downstream of process equipment.

18.5.4 Foundations

Temperature monitoring equipment and heating cables shall be provided where foundations supporting cryogenic containers and equipment could be adversely affected by freezing or frost heaving of the ground.

18.6 ADDITIONAL INSTRUMENTATION

In addition to the foregoing there shall be provided sufficient wall movement transducers, strain gages and temperature measuring instruments for floor, inner tank wall, outer tank insulation, roof and hung ceiling, and other indicators that the Fire Department may require, to assure the prompt detection of an LNG leak or variation from the normal operating parameters in any container.

18.7 EMERGENCY SHUT-DOWN

18.7.1 Power or Instrument Air Failure

Instrumentation for liquefaction, storage and vaporization facilities shall be designed so that in the event of power failure or instrument air failure the system will go into a "fail safe" condition until the system can be reactivated or secured.

18.7.2 Automatic Shut-Down

Provision shall be made for automatic shut-down of major items of equipment (e.g. compressors of a liquefaction facility, liquid send-out pumps and vaporizers and isolation valves), manually from several locations remote from the equipment and accessible in an emergency, and automatically in the event of fire detection or a major leak. In addition on fire detection, the emergency shut-down shall include automatic activation of the extinguishing system in the area of detection, and shall include automatic notification to the Fire Department

18.7.2 Automatic Shut-Down (Continued)

via a central office. The emergency shut-down shall be accompanied by audible and visible trouble signal at the control house and sounding of the plant alarm.

18.8 ELECTRICAL EQUIPMENT

18.8.1 General

Electrical equipment and wiring shall be of the type specified by and installed in accordance with the New York City Electrical Code and a certificate of inspection issued by the Bureau of Gas and Electricity shall be filed with the Fire Department. Where the New York City Electrical Code makes no provisions, NFPA Std. 70 shall apply. All alarm, detection, and communication systems shall conform to Section 21.8.1.b.

18.8.2 Secondary Electrical Power

A secondary source of electrical power shall be provided sufficient for LNG control, venting, plant shut-down, operation of fire protection equipment (including fire pumps). Gas turbine or diesel drive may be accepted as satisfying this requirement.

18.8.3 Electrical Grounding

All tanks, piping, and equipment shall be electrically grounded.

18.8.4 Lightning Protection

LNG storage tanks shall be protected against lightning in accordance with the New York City Electrical Code

18.8.4 Lightning Protection (Continued)

and NFPA Std. 78. An affidavit shall be filed to this effect with the Fire Department.

18.8.5 Warning Light

An explosion-proof red or amber warning light of adequate intensity shall be provided at the dome of the tank.

18.8.6 Stray Currents

If stray currents may be present, or if impressed currents are used in loading or unloading systems (e.g. cathodic protection) protective measures to prevent ignition shall be taken in accordance with "Protection Against Ignitions Arising Out Of Static, Lightning and Stray Currents" - API - RP 2003 (1967). Particular attention shall be given to protection of underground lines and structures from accelerated corrosion, and the use of insulated flanges to prevent currents, or use of bending cables to prevent potential differences at pipe and equipment interfaces.

18.8.7 Lighting

Lighting of adequate intensity shall be provided for all parts of the plant including the access roads to, and in the plant, and such lighting shall conform to the New York City Electrical Code.

19. TRANSFER OF LNG AND REFRIGERANTS

19.1 SCOPE

This section applies to the transfer of refrigerants, flammable liquids and flammable gases between storage containers or tanks and points of receipt or shipment as permitted by pipeline, tank car, tank vehicle or marine vessel, with the following restrictions:

a. LNG shall be received or shipped by Coast Guard approved marine vessel except where otherwise permitted by the Fire Department.

b. Flammable or combustible liquids, gases, or refrigerants shall be received only by approved pipeline or permitted trucks complying with the specifications of the Fire Department or by Coast Guard approved marine vessels.

c. Liquefied flammable gases shall be received only by Coast Guard approved marine vessels unless in containers complying with Article 17 of Chapter 19 Administrative Code.

d. Non-flammable gases, whether liquefied or not, shall be received only in permitted trucks complying with the specifications of the Fire Department, tank cars or Coast Guard approved marine vessels.

e. Transfer facilities shall comply with the appropriate provisions of these regulations relating to siting, piping systems, fire protection and instrumentation and to specific provisions of this section.

19.2 LNG COMPATIBILITY

LNG being transferred into storage containers shall be compatible with that already in the container. Means shall be provided to prevent stratification which may result in rollover and extensive evolution of vapor. The means of accomplishing this objective shall be acceptable to the Fire Department.

19.3 ODORIZATION

No gas in liquid or gaseous state shall be transferred into or out of the plant unless it is satisfactorily odorized.

19.4 PIPING SYSTEM

The transfer lines shall comply with the requirements of this section.

19.4.1 Blocking Valves

Blocking valves shall be provided at the extremities of marine liquid transfer lines. The valves at the discharging end may be manually operated. The valves at the receiving end shall be capable of remote shutdown and provided with "fail safe" features.

19.4.2 Precooling

Provision shall be made for precooling transfer lines used to convey cryogenic liquids.

19.4.3 Check Valves

Check valves shall be provided as required in transfer systems and located as close as possible to the point

19.4.3 Check Valves (Continued)

of connection to any system from which backflow can occur.

19.4.4 Vent Line

A vent line of sufficient capacity shall be provided for LNG transfer lines, fabricated of cryogenically suited materials, connected to the high point of the transfer line and vented to the flare system.

19.4.5 Supports

The liquid and vent lines shall be supported on incombustible supports. When steel is used, insulation shall be provided at points of contact. Cryogenic lines shall be insulated with incombustible insulation for personnel protection.

19.4.6 Vent Valve and Pressure Gage Location

Vent valves and pressure gages shall be provided equidistant along LNG lines at approximately 1000 foot intervals.

19.4.7 Transfer Line Fabrication

Transfer lines shall be fabricated of materials suited for the service intended, welded and 100% of all welds radiographed; when radiography is not possible, other nondestructive tests may be used. Expansion loops may be installed with flanges and gaskets and made up with stainless steel bolts. Piping shall conform to Section 17

19.4.7 Transfer Line Fabrication (Continued)

and stress level shall not exceed 40% of specified minimum yield strength.

19.4.8 Drains

A drain or bleeder valve shall be provided to empty piping after block valves are closed.

19.4.9 Pipe Routing

Where piping passes under roadways, ramps shall be provided and suitable protection to protect the pipe from impact loads. Such protection shall be in the form of a steel casing so that the transfer piping can be visually inspected for leaks.

19.5 PUMP AND COMPRESSOR DRIVE

19.5.1 Suitability

Pumps and compressors shall be designed and tested for the service temperatures and pressures to which they may be subjected.

19.5.2 Signal Lights

Signal lights shall be provided at the loading or unloading area to indicate when a remotely located pump or compressor used for loading or unloading is idle or in operation.

19.5 PUMP AND COMPRESSOR DRIVE (Continued)

19.5.3 Parallel Pumps

When pumps are in parallel, each pump suction and discharge line shall contain a block valve designed for at least the maximum operating pressure of the system. If centrifugal pumps are used, a check valve shall be placed between each pump discharge and the outlet block valve.

19.5.4 Shutdown Devices

In addition to the locally mounted devices for shutdown of the pump or compressor drive, a remote device readily accessible to the certificate of fitness holder supervising the transfer shall be provided to shutdown the pump or compressor in emergency. Remotely located pumps and compressors used for loading marine vessels shall be provided with controls at the loading area and at the pump or compressor site for shutdown.

19.6 MARINE SHIPPING AND RECEIVING

19.6.1 General

Design, construction and operation of piers, docks and wharves shall comply with the requirements of the Department of Ports and Terminals and the U.S. Coast Guard.

19.6.2 General Cargo

General cargo, other than ships stores for the LNG tanker shall not be handled over the pier within 200 feet of the

19.6.2 General Cargo (Continued)

transfer connection and no cargo shall be handled while LNG or flammable liquids are being transferred. Ship bunkering shall not be done over the same pier.

19.6.3 Vehicle Traffic

Vehicle traffic is prohibited on the pier or dock while transfer operations are in progress. Suitable warning signs and barricades shall be posted at all points of access to the pier when transfer operations are in progress.

19.6.4 Pipeline Location

Pipelines shall be located on the pier in such manner that they are not exposed to physical damage from any source.

19.6.5 Isolation Valves and Bleed Connections

Isolation valving and bleed connections shall be provided at the loading or unloading manifold for both liquid and vapor return lines so that hoses and arms can be blocked off, drained or pumped out and depressured before disconnecting. Valves shall be located at the point of hose or arm connection to the manifold. Bleeds or vents shall discharge to a safe area such as the line to the flare stack.

19.6.6 Block Valves

In addition to the isolation valves at the manifold, each vapor return and liquid transfer line shall be provided with a readily accessible block valve, on shore where the line approaches the dock or pier. Where there is more than one line, valves shall be grouped close enough for fast manual operation but not so close that fire at one valve would endanger personnel required to operate the others. Valves shall be identified as to service. Valves shall be power operated from a remote point as well as manual.

19.6.7 Check Valves

Pipelines used for liquid unloading only shall be provided with check valves adjacent to the manifold isolation valve.

19.6.8 Vapor Return Line

The vapor return line shall connect to the vessel's vapor return connection.

19.6.9 Loading Arms and Hoses

Loading arms and hoses shall be constructed of material suitable for the product conveyed and the pressures to be encountered. Connections shall be capable of dry quick disconnect. Hoses shall be approved for the service and designed for a bursting pressure of not less than five times the working pressure.

19.6.10 Type of Hose and Pipe

Flexible metallic hose or pipe and swivel joints shall be used. Couplings shall be suitable for operating conditions and fabricated of durable materials.

19.6.11 Loading Arm Supports

Loading arms and hoses shall be adequately supported. The design of counter-weights shall take into consideration the formation of ice.

19.6.12 Hose Testing

Hoses shall be tested at least semi-annually to the maximum pump pressure or relief valve setting and shall be visibly inspected before each use for damage or defects.

19.6.13 Vessel Transfer Precautions

Prior to transfers, an English-speaking officer of the vessel in charge of cargo transfer and the shore terminal supervisor shall personally inspect their respective facilities to ensure that transfer equipment is in proper working condition. After being satisfied that their inspections disclose no defect or cause for concern, they shall agree on safe transfer procedures and review the emergency procedures, including verification of ship-to-shore communications.

19. TRANSFER OF LNG AND REFRIGERANTS (CONTINUED)

19.7 ADDITIONAL PRECAUTIONS

In addition to the fixed fire protection required by these regulations the following precautions and procedures shall be followed in regard to marine loading or unloading of LNG:

a. At least 72 hours before the arrival of any tanker or barge, the Coast Guard and the New York Fire Department shall be notified of the date, time and point of entering the Port of New York for the purpose of organizing an escort for the vessel, if required, or standby fire protection.

b. No loaded vessel shall enter the Port or traverse its waters after sundown or before sunrise, or in inclement weather without the approval of the Coast Guard and concurrence by the Fire Department.

c. Except as permitted by the Coast Guard no loaded vessel shall enter the Port if hazard exists due to heavy traffic, congestion, or waterfront fires which endanger passage.

d. No vessel shall be docked for loading or unloading until inspected and certified by the Coast Guard.

e. Except as permitted by the Coast Guard no vessel shall enter the Port under unfavorable tide conditions. Sufficient tugboats to control the vessel shall be provided at all times.

f. Half-hourly patrols of the transfer line shall be made by operating personnel with certificates of fitness in vehicles

19.7 ADDITIONAL PRECAUTIONS (Continued)

equipped with 2-way radio and portable dry chemical extinguishers and lights.

g. Means shall be provided at the pier to transmit an alarm to the Fire Department.

h. A dry chemical fire truck conforming to Section 21.4.6 with operating personnel shall be stationed on the pier near the LNG manifold, continuously during LNG transfer.

i. Vessels and loading arms shall be electrically bonded.

j. Warning signs in lettering large enough to be seen from the channel shall be posted at each end of the pier or dock to inform approaching vessels of the transfer operation.

k. No vessel larger than 30,000 barrel capacity shall transfer LNG on a dead-end waterway.

19.8 TANK VEHICLE LOADING AND UNLOADING FACILITIES

19.8.1 Loading Facility

Loading and unloading facilities shall comply with the applicable provisions of Chapter 19 and Chapter 26 of the Administrative Code and applicable provisions of the Zoning Resolution.

19.8.2 Tank Vehicles

Tank vehicles shall load or unload flammable or combustible liquids only after they have been inspected and

19.8.2 Tank Vehicles (Continued)

authorized by the Fire Department and when in charge of a person with a certificate of fitness.

19.9 PIPELINE DELIVERIES OF FLAMMABLE OR COMBUSTIBLE LIQUIDS

19.9.1 Pipelines

Petroleum pipelines delivering flammable or combustible liquids to LNG Plants or related facilities shall comply with the regulations of the Fire Department.

19.9.2 Storage Tanks

Tankage for the storage of flammable or combustible liquids and/or petroleum products for LNG plants or related facilities shall comply with the applicable requirements of Article 8 of Chapter 19 of the Administrative Code.

19.10 COMMUNICATIONS

Communications shall be provided at a loading or unloading location so that the operator can be in contact with other remotely located personnel who are associated with the loading or unloading operation and with the control house. Communication shall be by means of telephone, public address or two-way radio with audible alarm signals which can be heard throughout the plant actuated at the control house in case of emergency.

20. TESTING AND TESTING PROCEDURES

Testing and testing procedures shall conform to the requirements of this section.

20.1 SYSTEM TESTING

System and sub-systems of piping in the plant, previously tested hydrostatically or pneumatically, and equipment interconnected by such piping, will be combined to form total integrated systems as dictated by process and plant operation conditions, and given a pneumatic holding test in the presence of a Fire Department Inspector to assure tightness of the system and its joints. The test pressure for each system shall be the highest pressure possible (above operating pressure) which will not disturb relief valves at their normal settings, nor machinery seals, nor exceed equipment design limitations. Systems to be tested prior to any plant start-up operation shall include (but not be limited to):

a. Natural Gas Pretreatment and Liquefaction System
b. Natural Gas Boiloff, Recondenser and Recompression System
c. LNG Product Sendout System
d. LNG Loading and Unloading Systems
e. Vent Header Collection System
f. Instrument Air System
g. Nitrogen Purge System
h. Cooling Water System

Test charts and affidavits covering these tests shall be submitted to the Fire Department.

20.2 LNG CONTAINERS 15 PSIG OR LESS

20.2.1 Initial Container Tests

The double and single roof containers operating at 15 psig or less shall be tested before placing in operation by filling with water to the top of the shell and applying an overload air pressure of 1.25 times the pressure for which the vapor space is designed. Container design shall be such that under such test conditions maximum fill shall not produce a stress in any part of the tank exceeding 80% of specified minimum yield strength or 50% of the specified minimum tensile strength of the material. In addition, the outer shell and roof test procedure shall be in accordance with Q8.2.1 of API 620, Appendix Q, July 1973.

20.2.2 Inner Containers Retest

Inner containers shall be hydropneumatically tested every five years, or in lieu thereof metal containers may be tested by the Charpy Impact Test method as follows:

a. As many samples as the Fire Department may deem necessary shall be cut from sheets of metal used in the construction of the container including a number of welded samples.

b. Samples shall be placed in a basket and continuously immersed in LNG contained in the tank.

20.2.2 Inner Containers Retest (Continued)

c. Three samples shall be withdrawn in the presence of a representative of the Fire Department in accordance with the following schedule:
At the end of six months, one year, two years, three years, five years and every five years thereafter.

d. On being withdrawn, samples shall be maintained at the proper temperature and tested promptly by a laboratory acceptable to the Fire Department. A report of the result in affidavit form shall be submitted to the Fire Department.

e. This does not preclude the requirement for a hydro-pneumatic test at any time should the Fire Department feel the necessity thereof.

20.3 LNG CONTAINERS - MORE THAN 15 PSIG

LNG containers operating at more than 15 psig, associated vaporizers and piping shall be tested hydrostatically, prior to being placed in operation, and every five years thereafter at two times the maximum operating pressure, except that if the resultant test pressure would exceed 300 psi, the test pressure shall be reduced to 1-2/3 times the maximum operating pressure.

20.4 PNEUMATIC PRESSURE TESTING OF CONTAINERS

The following steps should be observed when performing a pneumatic pressure test:

20.4 PNEUMATIC PRESSURE TESTING OF CONTAINERS (Continued)

a. Apply to the enclosed space above the water level an air pressure equal to 1.25 times the pressure for which the vapor space is designed.

b. Hold test pressure for 1 hr.

c. Reduce air pressure to equal design pressure.

d. Above the water level, check with soap film, linseed oil, or other suitable material all welded joints, all welds around openings, and all piping joints against which the pneumatic pressure is acting. A visual inspection may be substituted for the soap film inspection of the welded joint if previously checked with liquid penetrant or with a vacuum box. The soap film inspection shall still be made, above the water level, of all welds around openings, all piping joints, and the compression ring welds including the attachment welds to the roof and shell.

e. Check the opening pressure or vacuum of the pressure and vacuum-relief valves by pumping air above the water level and releasing the pressure, followed by a partial withdrawal of water from the tank.

f. Recheck and retighten the anchor bolts, if provided, after the tank has been emptied of water and is at atmospheric pressure.

20.4 PNEUMATIC PRESSURE TESTING OF CONTAINERS (Continued)

g. Apply air pressure, equal to the design pressure, to the empty tank and check the anchor bolts, if provided, and foundation for uplift.

h. Inspect all welded seams in the bottom and the corner weld between the shell and bottom, by means of a soap film and vacuum box test.

20.5 PIPING

20.5.1 <u>Hydrostatic Testing and Alternates</u>

Piping shall not leak when hydrostatically tested in the presence of a representative of the Fire Department for one hour at 200% (2X) maximum operating pressure or 100 psi whichever is greater. In lieu of a hydrostatic test, cryogenic piping, instrument air piping, derime system and dry chemical systems piping shall not leak when tested pneumatically (in conjunction with a soap and halide test) for one hour, as follows:

a. External cryogenic piping (outside of cold box) - 200% of design pressure (minimum 100 psi).

b. Internal cryogenic piping (inside of cold box) - 150% of design pressure, but not less than 200% of operating pressure (minimum 100 psi).

c. Instrument air piping - 200% of design pressure (minimum 100 psi).

20.5.1 Hydrostatic Testing and Alternates (Continued)

d. Derime system - 200% of design pressure (minimum 300 psi).

e. Dry chemical piping - 150% of design pressure but not less than 200% of operating pressure (minimum 100 psi).

f. Transfer lines and arms for LNG - 200% of operating pressure (minimum 200 psig).

20.5.2 Pneumatic Testing - Piping

Pneumatic testing shall be conducted as follows:

a. Introduce air or dry nitrogen into the system and raise pressure to 50 psi to determine if major leaks exist. Repair any leaks found.

b. Release the pressure in the system. Introduce freon up to 15 psi. Admit air or nitrogen and raise the system to the proper test pressure.

c. Inspect the system for leaks with a soap solution and then with halide (freon) leak detecter. Repair leaks found at this time, and retest.

d. Upon completion of steps a, b, c, apply the pneumatic holding test at the prescribed test pressure for one hour. This test to be witnessed by a representative of the Fire Department.

20.5.2 Pneumatic Testing - Piping (Continued

e. At conclusion of test, piping and associated equipment shall be purged with nitrogen.

f. Soap and halide tests may be witnessed or spot-checked by a Fire Department representative but all pressure tests shall be witnessed.

g. Affidavits shall be submitted at the conclusion of each test certifying that each has been carried out according to the requirements of the Fire Department.

20.6 ON-SITE TESTS

All on-site tests shall be witnessed by a representative of the Fire Department and test charts, and affidavits submitted.

20.7 FIRE PROTECTION SYSTEMS

Operational tests of all fire protection systems shall be made in the presence of a representative of the Fire Department including but not limited to:

a. Yard hydrant systems

b. Sprinkler and deluge systems

c. Fire pumps

d. Dry chemical and foam systems

e. Water spray systems

f. Fire detectors and alarm systems

g. Combustible gas detectors and alarm systems

h. Plant fire trucks

20.7 FIRE PROTECTION SYSTEMS (Continued)

i. Emergency shutdown systems as described in Section 18.7.

j. Electrical and communication systems

k. Leak detection and alarms

21. FIRE PROTECTION AND SAFETY

This section covers the minimum equipment and procedures required to control, extinguish and minimize the effects of fires and leaks or spills of LNG, flammable refrigerants, liquids or gases and are in addition to previously stated requirements for dikes, impounding areas, blocking valves or other similar provisions.

21.1 BASIC FIRE PROTECTION

21.1.1 General

The basic fire protection consists of the following:

a. Yard hydrant systems

b. Water spray and deluge systems

c. Dry chemical systems

d. Foam systems

e. A trained fire brigade

f. A training manual and pre-fire plan

g. Alarm systems for detecting combustible gas and fires and means for notifying the Fire Department.

h. Control of ignition sources

21.1.2 Periodic Testing

Operational retests of fire protection systems shall be made annually, witnessed by a representative of the Fire Department.

21.2 YARD HYDRANT SYSTEMS

Every LNG facility shall be protected by a system of yard hydrants with hose provided throughout, including marine transfer locations, 21.2 YARD HYDRANT SYSTEMS (Continued)

installed, tested and approved in accordance with the requirements of the Administrative Building Code, except, that when it is proven to the satisfaction of the Fire Department that due to the nature of the soil, excessive corrosion of mains will occur, piping fabricated of corrosion resistant material such as asbestos cement pipe may be accepted, but the code requirements for test pressure shall be maintained. Hydrants shall be fed from a minimum 10" looped main. Monitor nozzles shall be located as required by the Fire Department.

21.2.1 Hydrants

Hydrants shall be of the "New York City" type with two 2-1/2" Fire Department male threaded outlets with hydrant spacing according to the Code, except that hydrants and mains shall not be placed within impounding areas.

21.2.2 Water Supply

Where the water supply is from salt water, no connection to a city water main is permitted.

21.2.3 Fire Pumps

21.2.3.1 General

Fire pumps shall be installed in a water pump house and shall be of sufficient capacity to supply all anticipated needs of the water systems required by the Fire Department.

21.2.3 Fire Pumps (Continued)

21.2.3.2 Power Sources

At least two fire pumps having alternate power sources, one of which shall be electrical, shall be provided.

21.2.3.3 Fire Pump House Location

The fire pump house shall be located as remotely as possible and in accordance with the distances as shown in Figure 1, Section 4.1.

21.2.3.4 Fire Pump House Protection

The pump house shall be of incombustible construction and protected by an outside deluge system designed to maintain the interior temperature at a level no higher than can be endured safely by a pump operator and the pumping and electrical equipment.

21.2.4 Salt Water Supply

When the hydrant supply is salt water, the salt water supply shall be taken from coffer dams and inlets thereto protected by noncorrodible mesh screens capable of screening out all debris over 1/2" in cross-section. Such screens shall be removable for cleaning.

21.2.5 Drafting Site

Adjacent to the salt water pump house, a drafting site shall be maintained for the use of the largest Fire

21.2.5 Drafting Site (Continued)

Department pumper. Such site shall be built according to the requirements of the Fire Department. Suction connections shall be 12" plain for superpumper use and 4-1/2" male New York Fire Department threaded for regular land engines.

21.2.6 Drafting Site Manifold

A manifold shall be installed at the drafting site whereby the Fire Department may augment the yard salt water hydrant system by a land engine. The manifold design shall include eight 4-1/2" female swivel inlets and four 3" female swivel inlets (New York Fire Department threads).

21.2.7 Fireboat Facilities

Provision shall be made for mooring a New York City fireboat as near as possible to the salt water pump house, subject to the approval of the Fire Department and a manifold consisting of six 3-1/2" Fire Department threaded, female swivel, valved connections, shall afford the capability of augmenting the yard hydrant system by a fireboat.

21.2.8 Land Engine Facilities

At least two siamese connections, with Fire Department threads, each having two or more 3" female swivel inlets with New York Fire Department threads, shall be provided for use by land engines for any yard hydrant system fed

21.2.8 Land Engine Facilities (Continued)

by City water. Owing to variable site conditions the proposed location of these siamese connections shall be submitted to the Fire Department for approval.

21.2.9 Check Valves

Check valves shall be installed in all inlets to the system.

21.3 WATER SPRAY AND DELUGE SYSTEMS

Based on radiation studies noted in Section 4.1.1, exterior sprinkler systems shall be provided for buildings which could become untenable or where equipment could be damaged or rendered inoperable in event of a major LNG fire, e.g.: Control house, compressor, fire pump house, fireboat connection drafting site, and any building or location normally occupied or which requires personnel to be at their posts in emergencies.

21.3.1 System Operation

Each system shall operate automatically on fire detection anywhere in the plant when the ambient temperature on the outer face of the building reaches 135°F. Each system shall be capable of remote manual operation.

21.3.2 Tests

Operational and hydrostatic tests (at 200 psi) of all sprinkler, spray and deluge systems shall be witnessed by a representative of the Fire Department before acceptance.

21.3 WATER SPRAY AND DELUGE SYSTEMS (Continued)

21.3.3 Interior Sprinkler System

Buildings in which combustibles or inflammables are stored, and warehouses and garages shall be protected by an interior sprinkler system.

21.3.4 LNG Container Spray System

Every LNG container or tank required by these regulations to be bermed shall be protected by a water spray system completely encircling the roof at the top of the berm. This system shall have a two-fold purpose -

a. To reduce the effect of radiated heat to exposures in the event of fire in the tank.

b. To reduce the effect of radiated heat from another tank or tanks in a complex.

21.3.5 Nozzles

The number and arrangement of nozzles and the associated piping shall be subject to the approval of the Fire Department and based on radiation studies. Water supply shall be sufficient, and the pattern of distribution such, that the projected equilibrium temperatures will be achieved to the satisfaction of the Fire Department.

21.3.6 Water Screen Operation

The water screen shall operate automatically when fire detectors react to fire in the tank or any tank or diked

21.3.6 Water Screen Operation (Continued)

area, or the marine transfer area. For other areas, an override permitting a delay not exceeding five (5) minutes may be provided for operation of the water screen. All systems shall be capable of remote manual operation from the control house and near the system.

21.4 DRY CHEMICAL SYSTEMS

In all matters not specifically provided in this section, NFPA Std. 17, 1972 shall apply.

21.4.1 System Design

a. Systems shall be designed for a minimum flow rate of .035 pounds per second per square foot and a minimum time of discharge of 30 seconds.

b. Systems shall be engineered for each of the areas to be protected and plans filed with the Fire Department together with design and experimental data relative to range and effectiveness.

21.4.2 Typical Areas

Typical of areas requiring fixed dry chemical systems are:

a. LNG tank pump discharge

b. Vent gas compressors

c. Vent area of tank roof

d. Vaporizer booster pumps

e. Liquefaction unit and gas treatment unit

f. Vaporizer and regenerator heater areas

21.4.2 Typical Areas (Continued)

g. Marine loading arm areas

h. Loading and unloading areas

i. Run-off ditches and impounding areas

j. Other areas requiring fixed dry chemical protection shall be as specified by the Fire Department, and may be either automatically or manually activated.

21.4.3 System Operation

a. Except as may be otherwise provided for in systems required under Section 21.4.2-j, dry chemical fire extinguishing systems shall be actuated automatically immediately on fire detection without time delay or overrides. On actuation of the dry chemical system a visual and audible alarm signal shall be transmitted which will identify the system in operation. Each system shall be capable of remote manual operation, near the system and at the control house.

b. Operational and pneumatic tests shall be made of all equipment in the presence of a representative of the Fire Department.

21.4.4 Piping Protection

Piping shall be wrapped, cathodically protected, and buried with a minimum earth cover of three (3) feet or otherwise protected against mechanical injury, fire or

21.4.4 Piping Protection (Continued)

contact with LNG. Where piping passes under roads or ramps it shall be suitably protected with steel casings.

21.4.5 Nozzles

The number and type of nozzles shall be selected to provide complete coverage of the area or zone protected with the required concentration of dry chemical, in conjunction with the data required to be submitted under Section 21.4.1.

21.4.6 Fire Truck - Dry Chemical

A dry chemical mobile, self-powered, fire truck shall be provided for support operation of automatic systems and/or flexibility of operations in controlling LNG or surface Class A, B and C fires throughout the plant, in accordance with the following criteria:

21.4.6.1 Truck Capacity

The design of the truck and dry chemical unit shall be acceptable to the Fire Department, but shall be not less than 4000 pound dry chemical capacity.

21.4.6.2 Truck Equipment

The truck shall be outfitted with such equipment that it will be a self-sufficient unit; e.g., hose, nozzles, tools, lights, self-contained breathing apparatus, and extinguishers for handling small fires.

21.4 DRY CHEMICAL SYSTEMS (Continued)

21.4.7 Truck Operator

a. A qualified fire truck operator shall be on duty at all times without exception and the truck shall be stored indoors where it is easily accessible to the assigned personnel.

b. All operating employees shall be regularly drilled and trained in the operation of the vehicle and equipment.

c. The person in charge of the mobile unit shall obtain a certificate of fitness from the Fire Department.

21.4.8 Truck Restriction

The truck shall not be taken off the property except for major repairs in which event the Fire Department shall be immediately notified.

21.4.9 Truck Connection to Fixed Piping

Where the area protected by a fixed system is physically beyond the reach of hand hose lines from the mobile truck, an inlet to the fixed piping system shall be provided whereby the truck dry chemical unit can augment the system.

21.4.10 Portable Extinguishers

Such portable and wheeled dry chemical extinguishers shall be strategically located throughout the plant as

21.4.10 Portable Extinguishers (Continued)

may be required by the Fire Department. A program for monthly inspection and required recharging shall be established.

21.5 FOAM SYSTEMS

a. For the protection of pipe ditches and other impounding areas of limited size, a high expansion foam system may be installed in lieu of dry chemical, with the concurrence of the Fire Department.

b. In all matters not specifically provided in this section, NFPA 11A/1970, High Expansion Foam Systems, shall apply.

21.5.1 Foam System Capability

The foam system shall be capable of producing foam at a 500:1 ratio with discharge at a rate to cover the hazard to a depth of 5 feet within two minutes.

21.5.2 Foam System Supplies

Sufficient foam concentrate shall be provided to permit continuous operation for 30 minutes.

21.5.3 Foam Compatibility With Dry Chemical

The foam concentrate shall be compatible with dry chemical used to suppress LNG fires.

21.6 TRAINED FIRE BRIGADE

21.6.1 General

In every LNG facility a full time fire brigade shall be maintained consisting of operational employees thoroughly

21.6.1 General (Continued)

trained in the use of fire extinguishing equipment and tools and in the operation of the facility.

21.6.2 Safety Director

A safety director shall be employed whose duties shall be:

a. The correction of fire hazards which are brought to his attention in any manner.

b. The training of the fire brigade and responsibility for its manpower and efficiency.

c. The organization of a training manual which shall emphasize operational safety in every area of the plant.

d. Pre-fire planning, details of which shall be developed through liaison and regular combined drills with local Fire Department units under the supervision of the local deputy chief.

e. Maintenance of records of drills, training, lectures, incidents of any emergency nature, and copies of reports forwarded to supervisors. He shall immediately report, by telephone, every fire, leak, or spill, to the Division of Fire Prevention and follow with a written report. This shall be in addition to the normal transmittal of an alarm.

f. Establishment of a regular maintenance program for fire protection equipment, supervision of all maintenance and repair work to verify compliance

21.6.2 <u>Safety Director</u> (Continued)

with fire regulations. He shall have the authority and duty to stop all work being done in violation of Fire Department or company safety regulations.

21.6.2.1 Safety Director Selection

The safety director shall be selected on the basis of experience consisting of at least five years experience in a paid fire department, or in industrial fire protection and safety in a gas plant or bulk petroleum terminal or chemical refinery or in fire protection engineering or related fields.

21.6.2.2 Safety Director's Responsibility

The safety director shall be responsible to, and subject only to authority of top management; e.g., vice president status, in the performance of his duties.

21.6.2.3 Certificate of Fitness

The safety director shall obtain a certificate of fitness from the Fire Department qualifying him in this capacity and in the knowledge and operation of all protection systems.

21.6.3 <u>Deputy Safety Directors</u>

As many deputy safety directors shall qualify and be certified as are necessary to ensure that a Deputy Safety

21.6.3 Deputy Safety Directors (Continued)

Director will be on duty at all times when the Safety Director is off duty.

21.6.4 Fire Brigade

a. The fire brigade on duty at all times shall be selected so that a sufficient number is on duty to operate vital controls, start up fire protection systems should automatic devices fail, transmit alarms, secure the plant, extinguish incipient fires, and place equipment back in service when no longer required. In no case shall less than three men be on duty at any time.

b. A daily roster of members of the brigade in each shift shall be maintained, and every brigade member shall be aware of his assigned post and duties.

21.6.5 Protective Clothing

Protective clothing and asbestos suits shall be provided for all members of the brigade on duty. Additional asbestos suits or similar equipment shall be provided as required by the Fire Department.

21.7 TRAINING MANUAL AND PRE-FIRE PLANNING

21.7.1 Training Manual

A training manual for the fire brigade shall be submitted by the plant safety director to the Fire Department for acceptance.

21.7.2 Composition of Manual

The manual shall consist of the following:

a. Table of organization showing chain of command and levels of responsibility.

b. Drill schedule showing areas of plant, dates and times and showing that all members on duty must participate.

c. Standard drill operations, a short description of equipment and manpower requirements, and the objective.

d. Pre-fire plans and actions to be taken in event of fire, explosion or spills; e.g., a major leak in tank, a leak in LNG transfer line, a fire at pier during unloading, a compressor explosion.

e. Provision for first aid training.

f. Description of all fire safety systems, alarms, extinguishers, methods of operation and regular maintenance and tests.

g. Applicable fire department regulations, re: Welding, open flames, smoking, housekeeping, etc.

h. Emergency telephone numbers of City Departments, Coast Guard, and company personnel to be called.

21.8 ALARM SYSTEMS

21.8.1 General

a. Alarm systems shall be designed so that every portion of the area protected is under surveillance by the scanning or detecting devices, and shall be automatic in operation in that the device shall set in motion, without manual assistance the fire extinguishing systems designated for the area. If it becomes necessary to take any system off automatic; e.g., for repairs or alterations, the Fire Department shall be immediately notified.

b. Every alarm system shall be connected to the Fire Department via a central office, and the Fire Department shall be notified immediately of the transmission of an alarm. This means that the transmission of an alarm shall be followed by a telephone call from the control house to the Fire Department by using telephone number assigned by the Fire Department.

21.8.2 Alarm Boxes

Manually operated alarm boxes, in the number and locations specified by the Fire Department, shall be incorporated into the alarm system.

21.8 ALARM SYSTEMS (Continued)

21.8.3 Combustible Gas Detector System

21.8.3.1 General Operation

A combustible gas detector system shall be provided which shall sound an audible alarm at the location and a visual and audible alarm at the control house at 25% of the lower explosive limit. At 50% LEL emergency shutdown shall be initiated automatically placing the plant in "fail-safe" condition with simultaneous transmission of an alarm to the central office.

21.8.3.2 Combustible Gas Detector Locations

Combustible gas detectors shall be provided at the following typical locations (as well as additional locations required by the Fire Department upon examination of plans).

a. Control and auxiliary room
b. Compressor rooms
c. Liquefaction equipment
d. Gas treating equipment
e. Vaporizer booster pumps
f. Vent gas compressors
g. LNG pumps
h. Tank vents
i. At base of tank (at least one detector in each quadrant)

21.8.3.2 Combustible Gas Detector Locations (Continued)

j. At intervals along runs of LNG piping

k. Marine transfer points

l. Customer loading stations

m. High pressure gas inlets and outlets

21.8.4 <u>Fire Detection System</u>

21.8.4.1 General Operations

a. A fire detection "closed Circuit" system utilizing approved devices and equipment shall be provided throughout the plant which will give an audible and visual alarm in the control house, and indicate the location, and an audible alarm throughout the plant.

b. Such systems shall automatically actuate the fire extinguishing systems in the area involved, trip the plant to "fail-safe" and transmit an alarm to the Fire Department via an approved central office connection.

21.8.4.2 Ultra Violet Detectors

Ionization type or ultra violet detectors shall be used in buildings and ultra violet types outdoors. Other types of detectors acceptable to the Fire Department may also be used.

21.8.4 Fire Detection System (Continued)

21.8.4.3 Detector Locations

Fire detectors shall be provided at the following locations (in addition to others which the Fire Department may require on examination of plans).

a. Control and auxiliary rooms
b. Compressor rooms
c. Liquefaction equipment
d. Gas treating equipment
e. Vaporizer booster pumps
f. Vent gas compressors
g. Vaporizers
h. LNG pumps
i. Tank vents
j. At intervals along runs of LNG piping
k. Marine transfer points
l. Customer loading stations
m. High pressure gas inlets and outlets

21.8.4.4 Detector Shielding

Where it is impossible or impracticable to shield fire detectors from spurious responses consideration shall be given to the following options which shall be subject to approval of the Fire Department for each area protected:

21.8.4.4 Detector Shielding (Continued)

a. Shielding of detectors.

b. Installation in pairs, positioned to survey the protected area, and requiring response of both to a source of flame. Response of one detector alone shall only alarm but shall not initiate fire protection system or emergency shutdown.

c. Provision of a ten second delay which would require maintenance of the activating light source for ten seconds before initiating the alarm and extinguishing system (this is intended to prevent operation by a lightning flash or momentary reflected light).

21.9 CONTROL OF IGNITION SOURCES

21.9.1 Smoking, Welding and Hot Work

Smoking, or the carrying of lighted cigars, cigarettes or pipes, and the use of non process open flames within the plant area shall be prohibited with the following exceptions:

a. Smoking may be permitted in areas designated by the Board of Standards and Appeals under such conditions as it may impose.

21.9.1 Smoking, Welding and Hot Work (Continued)

b. Welding, cutting, and similar operations may be conducted at times and places specifically authorized by the Safety Director. No contractor shall be permitted to proceed with any repairs, alterations, or fabrication except under the authority of the Safety Director who shall see that all required permits or approvals have been obtained from the Fire Department, Department of Buildings, and/or Department of Ports and Terminals.

c. No welding, cutting, or similar hot work, or any repair, alteration, or testing shall proceed except when conforming to the provisions of applicable regulations of the Fire Department, Department of Buildings, and/or Department of Ports and Terminals.

21.9.2 Prohibited Use at LNG Spills or Leaks

The use of equipment, tools, or heating devices which are not approved for use in combustible atmospheres shall not be used in those areas where LNG has spilled or leaked.

21.10 HOUSEKEEPING

Good housekeeping for fire prevention, containment and access shall be maintained with emphasis on the following:

a. No rubbish, or brush shall be permitted to accumulate.

21.10 HOUSEKEEPING (Continued)

b. Storage shall be confined to storehouses, closets, lockers, or other approved locations.

c. Roadways shall be kept clear - no parking shall be permitted except in parking areas provided for employees, outside contractors, visitors, etc. Such parking areas shall be in locations acceptable to the Fire Department.

d. Dikes and berms shall be maintained at prescribed heights and contours.

e. Employees shall be directed to report all defects, malfunctions, breakdowns, and evidence of deterioration to superiors for correction.

21.11 REPAIRS, ALTERATIONS, INSPECTIONS, AND ENTRIES

All repairs, alterations, inspections, and entries by personnel into any vessel, tank, or container which has contained any flammable gas or liquid shall be made under inert atmospheric conditions as determined and certified by a Marine Chemist possessing a valid certificate issued by the National Fire Protection Association in accordance with NFPA Std. 306-1972 after his personal examination and testing. Such certification shall be made daily before start of any work in the vessel.

22. REQUIREMENTS FOR PLANS, APPROVALS, AFFIDAVITS, DOCUMENTATION

Specific data is required by the Fire Department to support certification of LNG facilities.

22.1 GENERAL REQUIREMENT FOR PERMIT

No permit or permission to operate an LNG facility to load or unload a container or vessel will be granted until the Fire Department is satisfied through approval inspections and the acceptance of required documentation that the regulations are complied with and no undue hazard exists. "Risk Analysis" of equipment or procedures shall be submitted as directed by the Fire Department.

22.2 RESIDENT PROFESSIONAL ENGINEER

The owner shall appoint a resident professional engineer who shall have authority to act as liaison with the Fire Department, file documents, comply with the Fire Department's requirements, file required reports and exercise resident supervision over construction, repair or modification and operation, during planning and construction and for a period of five years from completion.

22.3 DATA SUBMITTAL SCHEDULE

Plans, approvals, affidavits, documentation and other data shall be submitted on a schedule which will permit adequate review by the Fire Department and in accordance with the following paragraphs of this section.

22.4 PLANNING PHASE DATA

The following data shall be provided to support review of the Owner's application for approval of a LNG Project with New York City. Fire Department recommendations to the Board of Standards and Appeals for approval of this application will be based on analysis of this data.

22.4.1 Proposed Site Plan

A proposed site plan shall be filed with the Fire Department indicating all major characteristics of the site, showing plant buildings, tanks, containers, dikes, process areas, transfer areas, major LNG piping, lot lines, shore lines, and exposures within 1500' of lot lines. Such aerial photos as the Fire Department may require shall be included. Site plans shall include underground channels, conduits and such, as well as pipelines, drainage ditches and similar channels.

22.4.2 Description of Facility

A complete description of the facility shall be filed with the proposed site plan. It shall indicate the proposed quantities and methods of receiving, storing, processing and distributing LNG within the facility. A detailed analysis of the product to be stored shall be included. Fire protection, safety and operational control systems shall be indicated with statements as to the basis upon which each were selected.

22.4 PLANNING PHASE DATA (Continued)

22.4.3 Thermal Radiation and Vapor Dispersion Study

A thermal radiation and vapor dispersion study shall be submitted, prepared by recognized experts in thermodynamics acceptable to the Fire Department. The study should include vapor dispersion characteristics resulting from spills caused by major failure modes of the storage tanks, equipment, and piping. The radiation study should assume an entire tank or group of tanks are involved in a fire and should show equilibrium temperatures within a radius of 1500' of the tank, at wind velocities of 0, 30, and 60 mph, at points where R = 1500', 1200', 1000', 800', 600', 500', 400', 300', 200' and 100' from flame surface. Attention shall also be given to the possibility of local overheating and fires in impounding areas.

22.4.4 Fire Prevention Criteria Document

A Fire Prevention Criteria Document shall be submitted as a companion document to the Proposed Site Plan and the Description of Facility. It shall contain the criteria by which the owner, plans to meet the requirements of this regulation and all other requirements of the Fire Department. The document shall be maintained throughout the plant construction and start-up phase reflecting all major requirements of the Fire Department. Criteria shall be organized by plant and fire protection systems and shall include the following:

22.4.4 Fire Prevention Criteria Document (Continued)

a. Design and performance criteria.

b. Test plans and procedures.

c. Training requirements and Plans.

d. Operational plans and Procedures.

e. Compliance, Approvals and Affidavits.

22.5 DESIGN PHASE DATA

The following data shall be provided to support review of the Owner's application to build a LNG Plant within New York City. Fire Department recommendations to the Department of Building or Department of Ports and Terminals for approval of the building permit(s) will be based on the analysis of this data.

22.5.1 Construction Drawings

a. The Fire Department shall have access to all site plans, construction drawings, equipment drawings, installation drawings, specifications and other data utilized by the Contractor(s) for construction of the plant. The Fire Department shall be provided, on request, copies of the above data required for their reviews and analyses, and plans shall be filed for approval with the Department of Ports and Terminals or Department of Building.

b. Copies of venting and relief valve calculations for LNG storage tanks shall be furnished.

22.5.1 Construction Drawings (Continued)

c. Data on power needs and secondary power capacity to provide power for LNG control, venting, plant shutdown, fire protection systems (including fire pumps).

d. Plans showing locations and construction of Fire Department siamese manifolds and suction connections, hydrant systems, dry chemical systems, water spray systems, foam systems, gas and fire detectors, alarm and communication systems shall be submitted to the Fire Department for acceptance.

22.5.2 Process Report

A process report shall be filed with the Fire Department, for review; such report shall contain the following:

a. Process information on incoming feed gas treatment, refrigeration, liquefaction, vaporization, deriming, and odorization.

b. Basis for approval of all equipment used with reference to the standards of construction, e.g. ASME, ANSI, Chapter 19 Administrative Code, and Chapter 26, Administrative Code.

c. Suitability of materials of construction for the pressures and temperatures to be encountered by equipment, piping, valves, insulation.

22.5.2 Process Report (Continued)

d. Adequacy of safety features, including temperature and pressure relief, instrumentation and control panels, emergency shut down and fire shut down devices, isolation valves, dump tanks, flare stacks, electrical equipment and test procedures.

e. Plot plan showing location of each piece of equipment, valves, piping, safety devices, instrumentation, etc., and distances between equipment, tank, property lines, open flames, etc.

f. Flow charts which shall show all equipment, safety devices and instrumentation with pressure and temperature at all points to be indicated.

g. Equipment summary sheets or charts for each piece of equipment, safety and relief device, valve, piping, etc., indicating its function, operating pressure and temperature, material of construction, insulation, and safety devices.

h. Relief device calculations shall be included as well as support ASME and manufacturers' affidavits.

22.5.3 Fire Protection Report

a. A manual for training the fire brigade shall be submitted for acceptance by the Fire Department. The manual shall designate and include the duties

22.5.3 Fire Protection Report (Continued)

of the Safety Director, Deputy Safety Director, fire brigade personnel. It shall describe the functions, operations, maintenance and tests required for all fire protection and prevention in the facility.

22.6 DESIGN COMPLIANCE, APPROVALS AND AFFIDAVITS

Affidavits shall be provided by the Company, the Architectural and Engineering firm and the Engineer of Record that the plant design in in compliance with the following:

a. The design conforms to NFPA 59A, 1972 in all respects not covered herein.

b. Construction is in accordance with the New York City Building Code, Chapter 26, Administrative Code, and any applicable Board of Standards and Appeals Resolution.

c. All compressed gas vessels (air, nitrogen, etc.) shall conform to Article 17, of Chapter 19 of the Administrative Code and any applicable resolution of the Board of Standards and Appeals.

d. All refrigeration equipment shall conform to the requirements of Chapter 26 Administrative Building Code with the provision that where mixtures of flammable gases or liquids not listed therein are used as refrigerants, approval from a nationally recognized testing laboratory shall be submitted with a request for acceptance. Refrigerant vessels shall conform to the ASME Code and refrigerant piping, fittings and relief devices shall conform to ANSI B31.5 or ANSI B31.8.

e. All pipe joints shall be welded by certified welders and radiographed. Certifications of welders and welds shall be filed with the Fire Department.

f. Electrical lighting, wiring, equipment and devices conform to the New York City Electrical Code, Chapter 30, Administrative Code.

g. LNG storage tank is to be protected against lightning in accordance with the New York City Electrical Code and NFPA-78.

h. All materials are suitable for the temperature and pressure involved.

i. All equipment and devices (including LNG pumps) are of approved type (approved by the Board of Standards and Appeals or other acceptable nationally recognized testing organization, such as Underwriters Laboratories, Factory Mutual, Factory Insurance Association, U.S. Coast Guard, etc.)

j. Lubricating oil tanks shall conform to the requirements of Chapter 26, Administrative Building Code, and the regulations of the Fire Department.

22.6 DESIGN COMPLIANCE, APPROVALS AND AFFIDAVITS (Continued)

k. Color coding of piping systems shall meet the requirements of the Fire Department.

22.7 CONSTRUCTION AND PLANT START-UP PHASE DATA

The following data is required by the Fire Department to assure that all construction meets the requirements for safe operation and that trained personnel and adequate procedures are available for plant operation. No permit for start-up operations shall be given until these are complied with.

22.7.1 Test Data

The results of operational, hydrostatic and pneumatic test shall be submitted in the form of test charts and/or reports signed and dated by the company representatives and Fire Department representative witnessing the tests.

22.7.2 Construction Approvals and Affidavits

Evidence of Approval and Affidavits shall be provided by the resident engineer that all construction has been accomplished in accordance with the design requirements stated in Section 22.6.

22.7.3 Data Required Prior to Cooldown and Start-up (Debugging Stage)

a. A survey of the plant by a licensed surveyor shall be filed with the Fire Department showing the location of the LNG tanks, all equipment and buildings

22.7.3 Data Required Prior to Cooldown and Startup (Continued)

and indicating that all distance and topographical requirements have been complied with.

b. Evidence of approval by the Department of Ports and Terminals, or Department of Building, whichever has jurisdiction shall be submitted to the Fire Department showing that the LNG tanks, berms and dikes have been constructed according to approved plans and the requirements of all agencies having authority and jurisdiction. Supporting affidavits shall be submitted by the owner, the engineer of record, and the contractors stating that the tanks have been so constructed and are suitable and safe for the purpose intended.

c. An affidavit shall be submitted by the owner and the engineer of record that all requirements of the Fire Department and any other regulatory agency have been complied with.

d. At least two responsible employees on each shift shall obtain certificates of fitness from the Fire Department to supervise the operation of the facility. Such employees shall be selected on the basis of knowledge and experience in LNG plant operation, and fire protection systems, refrigeration systems, processing, maintenance and repair, and transfer operations.

22.8 OPERATIONS PHASE DATA REQUIREMENTS

The following data is required prior to approval for the initial or renewal operating permit by the Fire Department.

22.8.1 Permit

An annual Fire Department permit shall be obtained, the fee to be in accordance with C19.24.0 of the Administrative Code.

22.8.2 As-Built Approved Plans

The Fire Department shall be provided with a copy of the as-built approved plans which shall include:

a. Plot plans

b. Tank plans

c. Process area plot plan

d. Fire protection systems plans showing yard hydrants and mains, dry chemical, water deluge, sprinklers, water curtains, foam systems, water supplies, pumps, combustible gas detection systems and other alarm systems, underground piping, channels, conduits, ducts or sewers.

e. Plans showing structural features

f. As-built survey

g. Radiation and vapor dispersion studies

22.8 OPERATIONS PHASE DATA REQUIREMENTS

22.8.3 Reports

a. A semi-monthly progress report shall be submitted to the Fire Department by the engineer of record after the start of operations indicating the status of the plant, any deviations from normal operations, incidents, malfunctions, etc.

b. A quarterly report shall be submitted to the Fire Department by the owner and engineer of record indicating alterations and changes at the plant and the reasons therefor, malfunctions and the reasons therefor, and an instrumentation study and analysis. The semi-monthly reports shall be continued until the Fire Department is satisfied that they are no longer necessary.

22.8.4 Operating Data and Test

a. An affidavit shall be submitted indicating maximum density of LNG to be stored.

b. A program shall be submitted for the periodic Charpy testing of samples immersed in the LNG as required by Section 20.2.2.

c. Procedures shall be submitted for acceptance of all purging operations.

23. MODIFICATIONS

Whenever circumstances, conditions, limitations, or surroundings are unusual, or such as to render it impracticable to enforce all the foregoing requirements, the Commissioner of the department having jurisdiction may waive or modify such provisions to such extent as he may deem necessary consistent with public safety, with the concurrence of the Fire Department.

24. SAVING CLAUSE

If any clause, sentence, paragraph, section or part of this article shall be adjudged by any court of competent jurisdiction to be invalid, such judgment shall not affect, impair or invalidate the remainder thereof, but shall be confined in its operation to the clause, sentence, paragraph, section or part thereof directly involved in the controversy in which such judgment shall have been rendered.

REFERENCES

ACI - American Concrete Institute

614-59 - Recommended practice for Measuring, Mixing and Placing of Concrete

525-63 - Minimum Requirements for Thin-Section Precast Concrete Construction

318-63 - Building Code Requirements for Reinforced Concrete

506-66 - Recommended Practice for Shotcreting

XXX - ACI Committee Report 344 - Design and Construction of Circular Prestressed Concrete Structures

311-64 - Recommended Practice for Concrete Inspection

ANSI - American National Standard Code for Pressure Piping (American Society of Mechanical Engineers)

B-31.3 - Petroleum Refinery Piping - 1966

B-31.5 - Refrigeration Piping Systems - 1967

B-31.8 - Gas Transmission and Distribution Piping Systems - 1968

API - American Petroleum Institute

620 - Recommended Rules for Design and Construction of Large, Welded Low Pressure Storage Tanks

Appendix Q - Low Pressure Storage Tanks for Liquefied Natural Gas - July 1973

1104 - Standard for Welding Pipelines - 1968

6D - Standard for Pipeline Valves - 1968

ASME - American Society of Mechanical Engineers Boiler and Pressure Vessel Code

Section VIII - Unfired Pressure Vessels - 1971

Section IX - Qualification of Welders - 1971

MSS - Manufacturers Standardization Society of the Valve and Fitting Industry

SP-6 - Standard Practice - 1963

NFPA - National Fire Protection Association - Standards

11A - High Expansion Foam Systems - 1970

17 - Dry Chemical Systems - 1972

37 - Installation and Use of Stationary Combustion Engines and Gas Turbines - 1970

59A - Production, Storage and Handling of Liquefied Natural Gas - 1972

68 - Guide for Explosion Venting - 1954

78 - Lightning Protection Code - 1968

306 - Control of Gas Hazards on Vessels - 1972

SECTION II

APPENDIX A

NYFD RISK MANAGEMENT PROVISIONS FOR DESIGN, FABRICATION AND OPERATION OF LIQUIFIED NATURAL GAS FACILITIES

Table of Contents

1. INTRODUCTION

This publication establishes common risk management provisions for the design, fabrication, and operation of LNG facilities in New York City.

Applicants for Fire Department permits shall use this publication as the basis for obtaining approval as well as a guideline for their activities to minimize LNG hazards. Consideration shall be given to the requirements and scheduling for mandatory reports and documentation. The application of engineering and management disciplines by which the New York Fire Department shall ensure that safety requirements have been fulfilled shall be considered to be risk management.

Figure 1 shows the relationship of this instruction within the documentation tree of the Risk Management System. Figure 2 illustrates the responsibilities associated with the implementation of this system.

2. RISK MANAGEMENT

The NYFD Risk Management System consists of the following activities:

a. Hazard identification

b. Hazard analysis and problem resolutions

c. Contingency planning

d. Status reporting

e. Project review

As shown in Figure 3, the project review is the culmination of activities for each phase and will provide the process of obtaining Fire Department acceptance or approvals required to enter the next phase of facility development. Details of how the NYFD will operate the Risk Management System are given in the document "Operating Instructions - NYFD Risk Management System for LNG".

3. GENERAL CONSIDERATIONS

The owner shall maintain a design, installation, and operational capability to satisfy the requirements of the New York City "Regulation for Manufacture, Storage, Transportation, Delivery and Processing of Liquefied Gas". In addition, the owner shall provide documentation describing how he will assure the identification, elimination and/or control of potential hazards which could result in injury, loss of personnel, and/or facility destruction through all phases of facility development.

RISK MANAGEMENT SYSTEM DOCUMENT TREE

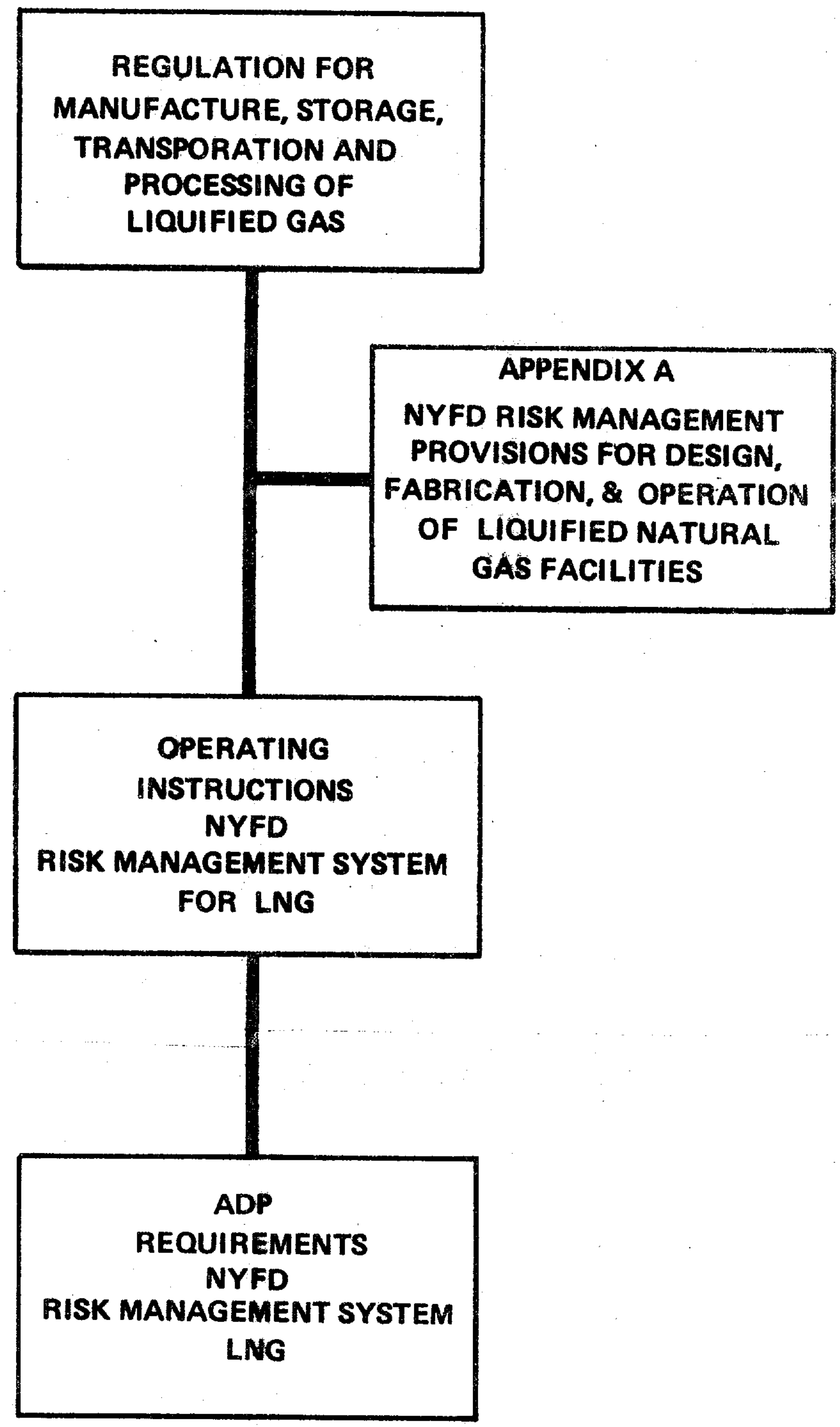


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FIGURE 1

RESPONSIBILITIES ASSOCIATED WITH RISK MANAGEMENT SYSTEM

OWNER (COMPANY)	• Basic planning, clearances with Governmental Agencies, and Funding • Consultants for special studies • Plant operations (systems verification testing, operational safety)
ARCHITECT & ENGINEER	• Design plant and operating systems • Special studies and analyses • On-site technical engineering support
CONTRACTOR(S)	• Build the plant • Install the plant systems • Conduct tests to verify workmanship
ENGINEER OF RECORD	• Prime company interface for the Fire Department. • Provide required approvals, certifications and affidavits • Initiate special studies and analyses, **provide on-site support**
NYFD	• Establish minimum requirements for safe operation • Monitor all phases of plant activity • Provide supplemental fire protection (contingency plans)

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FIGURE 2

RMS PHASE & PROJECT REVIEW IDENTIFICATION

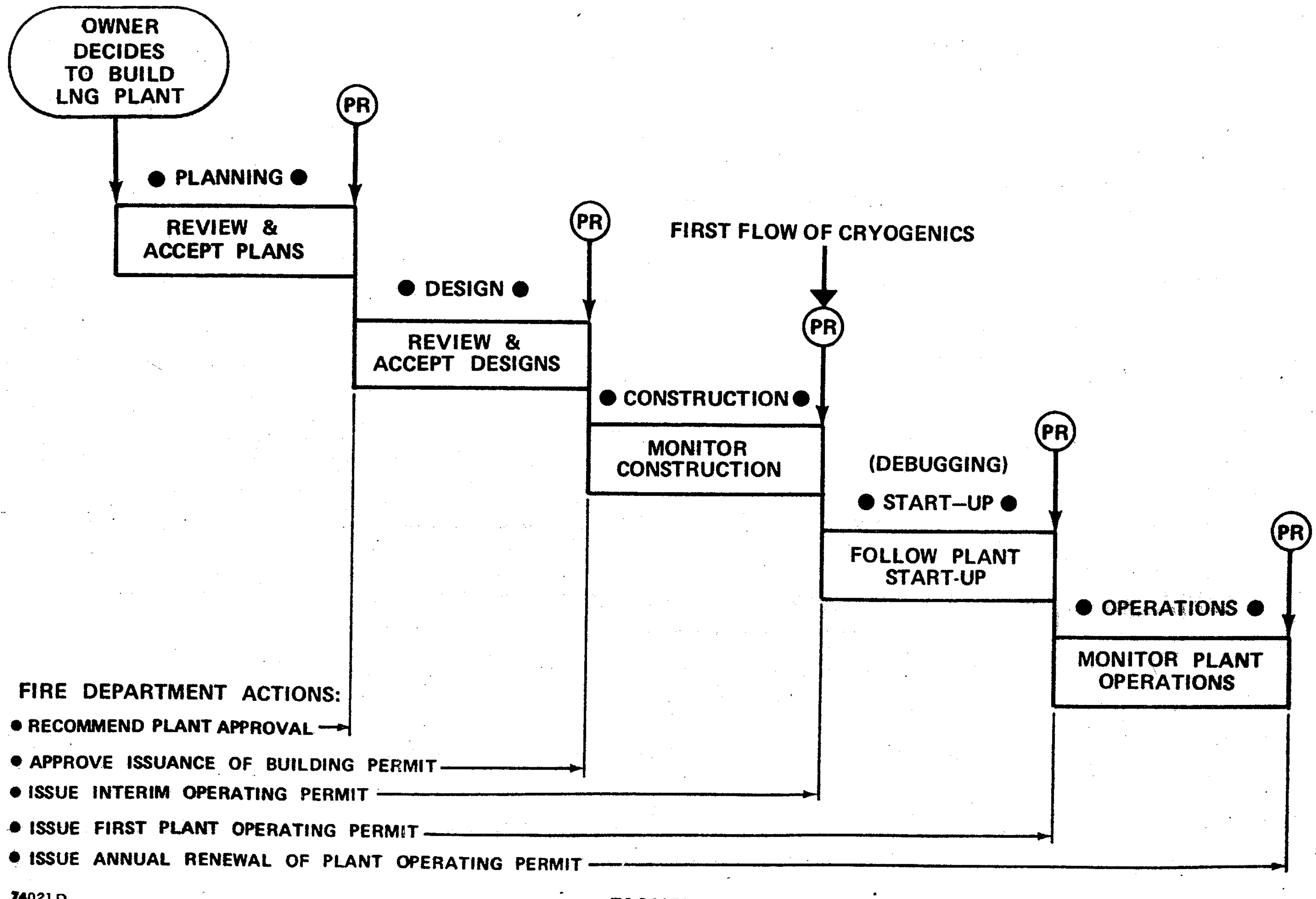

FIGURE 3

3. GENERAL CONSIDERATIONS (Cont'd)

The owner shall, as an integral part of his activities, implement safety requirements for planning, design, testing, and operations. He shall establish check points for management information in accordance with Figure 3 to assure that all safety considerations have been evaluated and completed prior to commencement of each project phase.

The owner shall establish a system to assure that there is compatibility of design, test and operational documentation with the "as-built" hardware.

Risk management requires hazard analyses be performed by a qualified organization to include as representative examples:

a. Radiation and vapor dispersion analyses

b. Detailed design analyses of critical systems, including results of failure mode effects analysis.

c. Finite element analysis

d. Verification that changes and modifications have been incorporated and compatible prior to critical system operation.

4. EVALUATIONS FOR NYFD

NYFD reserves the right to use representatives in its evaluations and audits of hazards and risk management at a licensed facility. These representatives may determine effectiveness of and recommend improvements to the owner's risk management and safety activities.

5. HAZARD ANALYSIS

The owner shall have performed qualitative analysis to identify significant hazards and assure their resolution. Hazards resulting from failures, irrespective of subsystem or component redundancy, shall be analyzed. In addition, hazards emanating from normal or emergency equipment operations, environment, personnel error, design characteristics, and credible accidents shall also be analyzed. The owner shall also identify and eliminate or control any failures or malfunctions that could independently or collectively present a hazard to interfacing equipment and assure that normal operation of a hardware item cannot degrade the safety of interfacing equipment or the total system.

6. ELEMENTS OF HAZARD ANALYSIS

In performance of the hazard analysis, consideration shall be given to at least the following elements:

6. ELEMENTS OF HAZARD ANALYSIS (Cont'd)

a. Isolation of energy sources/propagation paths.

b. LNG: It's characteristics, hazard levels, and quantity/-distance constraints, handling, storage, and transportation safety features, compatibility factors, etc.

c. Proposed system environmental constraints.

d. Effect of transient current, electromagnetic radiation and ionizing radiation. Design of controls to prevent inadvertent activation of initiation circuits.

e. Documentation for safe operation and maintenance of the system.

f. Training and certification pertaining to safe operation and maintenance of the system.

g. Egress, escape, rescue, survival of operational personnel.

h. Fire and explosion sources, detection, warning and protection.

i. Resistance to shock damage.

j. Toxicity sources - detection and warning.

k. Man-machine relationship.

l. System interactions.

m. Docking considerations/cargo handling.

n. Long-term storage.

7. HAZARD REDUCTION PRECEDENCE SEQUENCE

To eliminate or control hazards, the owner shall use as a minimum the following sequence or combination of items:

a. Design for Minimum Hazard. The major goal throughout the design phase shall be to ensure inherent safety through the selection of appropriate design features.

b. Safety Devices. Known hazards which cannot be eliminated through design selection shall be reduced to an acceptable level through the use of appropriate safety devices as part of the system, subsystem, or equipment.

c. Warning Devices. Where it is not possible to preclude the existence or occurrence of a known hazard, devices shall be employed for the timely detection of the condition and the generation of an adequate warning signal.

7. HAZARD REDUCTION PRECEDENCE SEQUENCE (Cont'd)

d. Special Procedures. Where it is not possible to reduce the magnitude of an existing or potential hazard through design, or the use of safety and warning devices, special procedures shall be developed to counter hazardous conditions for enhancement of personnel safety.

8. HAZARD CLOSURE CRITERIA

A hazard shall be considered closed only if:

a. The hazard has been eliminated by design and design accomplishment has been confirmed, or

b. The hazard has been reduced to an acceptable level (controlled hazard) in accordance with the Hazard Reduction Precedence Sequence, and this reduction has been verified by way of a successful completion of the required test programs, analytical studies, and/or training programs, or

c. The hazard has been assessed and the risk has been accepted by NYFD. Rationale for acceptance of catastrophic and critical hazards shall be documented by the owner for presentation at the Project Review.

9. RESIDUAL HAZARD

Hazard for which safety or warning devices and/or special procedures have not been developed or provided for counteracting the hazard.

10. HAZARD REPORTING

The owner shall establish a system to provide the status of all identified hazards. Catastrophic and critical hazards will be specifically identified. Continuation of effort to eliminate or reduce such hazards shall be accomplished throughout the program by maintaining awareness of new safety technology or devices being developed and their application to the reduction of hazard level.

Glossary of Terms

Accident - An unplanned event which results in an unsafe situation or operational mode.

Failure - The inability of a system, subsystem, component, or part to perform its required function within specified limits, under specified conditions for a specified duration.

Hazard - The presence of a potential risk situation caused by an unsafe act or condition.

Hazard Analysis - The determination of potential sources of danger and recommended resolutions in a timely manner for those conditions found in either the equipment or software procedures systems which could cause loss of personnel capability, loss of system, or loss of life or injury to the public.

Hazard Levels - A hazard whereby environment, personnel error, design characteristics, procedural deficiencies, or subsystem malfunction may result in loss of personnel capability or loss of system shall be categorized as follows:

1. Catastrophic - Loss of life or facility or no time or means are available for corrective action.

2. Critical - Major damage to facility or may be counteracted by emergency action performed in a timely manner.

3. Controlled - Has been counteracted by appropriate design, safety devices, alarm/caution and warning devices, or special automatic/manual procedures.

Interface - A common physical or functional boundary between two or more components, systems, programs, people or procedures.

Loss of Personnel Capability - Loss of personnel function resulting in inability to perform normal and/or emergency operations. Also includes loss or injury to the public.

Loss of System - Loss of the capability to provide the level of system performance required for normal and/or emergency operations.

Project Review - A meeting in which the status of the owner's compliance with Fire Department requirements is reviewed for each project phase. Fire Department acceptances and approvals are based on the results of these reviews.

Redundancy - The existence of more than one means for accomplishing a given task.

Glossary of Terms (Cont'd)

Risk - The chance (qualitative) of loss of personnel capability, loss of system, or damage to or loss of equipment or property.

Safety - Freedom from chance of injury or loss of personnel, equipment or property.

System Safety - The optimum degree of risk management within the constraints of operational effectiveness, time and cost attained through the application of management and engineering principles throughout all phases of a program.

SECTION III

OPERATING INSTRUCTIONS

NYFD

RISK MANAGEMENT SYSTEM

FOR LNG

BACKGROUND

The energy needs of the United States will require widespread uses of liquefied natural gas (LNG). The handling and storage of LNG imposes many new facility safety problems. The National Aeronautics and Space Administration (NASA) in the conduct of the Apollo and Skylab programs developed safety management techniques which contributed greatly to the safety of these missions.

The LNG "Risk Management System" (RMS) has been produced under the NASA Technology Utilization Program at Kennedy Space Center by NASA and Boeing Aerospace Company personnel who have participated in the development and use of these techniques in the management of hazardous materials facilities at KSC.

The RMS is prepared for use by the New York Fire Department who presently has a major responsibility for public safety associated with four large LNG facilities in various stages of planning, construction and operation.

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LIST OF ILLUSTRATIONS

DEFINITIONS

Component - A combination of electrical and/or mechanical parts, usually a self-contained entity which performs a discrete function in the overall operation of related equipment.

Fail-Safe - The design feature which provides for safe condition in the event of malfunction of control devices, detection of fire or gas leak, or interruption of an energy source.

Failure - The inability of a system, subsystem, component, or part to perform its required function within specified limits, under specified conditions for a specified duration.

Failure Mode and Effects Analysis (FMEA) - Identifies potential single point failure points within a system and categorizes the effect of failure.

Hazard - The presence of a potential risk situation caused by an unsafe act or condition.

Hazard Analysis - The determination of potential sources of danger and recommended resolutions in a timely manner for those conditions found in either the hardware or software systems which could cause loss of personnel capability, loss of system, or loss of life or injury to the public.

Hazard Levels - A hazard whereby environment, personnel error, design characteristics, procedural deficiencies, or subsystem malfunction may result in loss of personnel capability or loss of system shall be categorized as follows:

1. Catastrophic - Loss of life or facility or no time or means are available for corrective action.

2. Critical - Major damage to facility or may be counteracted by emergency action performed in a timely manner.

3. Controlled - Has been counteracted by appropriate design, safety devices, alarms/caution and warning devices, or special automatic/-manual procedures.

Interface - A common physical or functional boundary between two or more components, systems, programs, people or procedures.

Loss of Personnel Capability - Loss of personnel function resulting in inability to perform normal and/or emergency operations; also includes loss or injury to the public.

Loss of System - Loss of the capability to provide the level of system performance required for normal and/or emergency operations.

Project - The organized undertaking of planning, design, construction and operation of a LNG facility.

DEFINITIONS (Cont'd)

Project Review - A meeting in which the status of the owner's compliance with the Fire Department Requirement is reviewed for each project phase. Fire Department acceptances and approvals are based on the results of these reviews.

Redundancy - The existence of more than one means for accomplishing a given task.

Residual Hazard - Hazard for which safety or warning devices and/or special procedures have not been developed or provided for counteracting the hazard.

Risk - The chance (qualitative) of loss of personnel capability, loss of system, or damage to or loss of equipment or property.

Risk Analysis - A methodology of assessment of an identified hazard utilizing a systematic evaluation of failure modes, probabilities and consequences resulting in quantitative data supporting recommendations for corrective action.

Safety - Freedom from chance of injury or loss of personnel, equipment or property.

Start-Up Phase (Debugging) - The period of time during the activation of a LNG facility when the facility construction is ready for initial component cooldown and cryogenic flow and when final test and inspection activities are completed.

Subsystem - A grouping of components or equipment which is essential to the operational completeness of a system.

System - A composite of equipment skills and techniques joined together to support or perform a specific operational function or functions.

System Safety - The optimum degree of risk management within the constraints of operational effectiveness, time and cost attained through the application of management and engineering principles throughout all phases of a program.

ABBREVIATIONS

A&E	Architecture and Engineering
FMEA	Failure Mode & Effects Analysis
KSC	John F. Kennedy Space Center
LNG	Liquefied Natural Gas
MTTR	Mean-Time to Repair
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
NYFD	New York Fire Department
RMS	Risk Management System

1.0 INTRODUCTION

1.1 Purpose

The purpose of this instruction is to provide a description of the Risk Management System (RMS) and establish uniform requirements, criteria and procedures by which the New York Fire Department can implement the system.

It will guide Fire Department personnel in organizing the tasks normally associated with a Liquefied Natural Gas (LNG) facility activation such that potential hazards may be identified, analyzed and any risk reduced to an acceptable level.

It will focus attention on major risk areas, establish risk reduction techniques and assure management visibility relative to Fire Department requirements, resource limitations and other factors affecting a LNG project.

It will also serve as a guide to any LNG facility owner in supporting the New York Fire Department requirements for risk management.

1.2 Application

The Risk Management System and this instruction is applicable for all LNG facilities located or proposed within New York City.

1.3 Implementation

This instruction shall normally be implemented at the time an owner requests approval for an LNG project. For existing facilities, the instruction shall be implemented to meet current Fire Department risk management requirements.

2.0 RISK MANAGEMENT SYSTEM

2.1 General

The Risk Management System is defined as a methodology involving the application of scientific and engineering principles for:

a. The identification of hazards.

b. Evaluation of the risk involved.

c. Application of risk analysis techniques.

d. Elimination or reduction of the hazard to an acceptable level.

It provides for management review and decision making action through status reporting, monitoring, control and certification reviews.

The Risk Management System logic diagram (Figure 2-1) identifies the major functional areas, displays and the information flow through the system and the typical activities associated with each area.

2.2 Project Phase Identification

Major management decisions occur when it is required that the Fire Department accept, recommend or approve requests for permits by the owner to build and operate a LNG facility. In the RMS the LNG facility is divided into five phases based upon the key management decisions to be made: (1) Planning, (2) Design, (3) Construction (4) Start-Up, and (5) Operations. Figure 2-2 presents these phases. As shown, each phase culminates in a project review.

A definition of the phases and the resulting action by the Fire Department is given in the following paragraphs.

2.2.1 Planning Phase

During the planning phase the Fire Department and the Department of Ports and Terminals will review preliminary plans and descriptions. These reviews will establish basically that these departments have advised the owner of all requirements, and that the owner agrees to meet the requirements in the building and operation of his plant. Planning phase activities lead to the review of the owners preliminary plans and recommendations to the New York Board of Standards and Appeals or the agency having jurisdiction for approval of the project.

2.2.2 Design Phase

During the design phase, after concept approval by New York Board of Standards and Appeals, the Fire Department and Department of Ports

RISK MANAGEMENT SYSTEM LOGIC

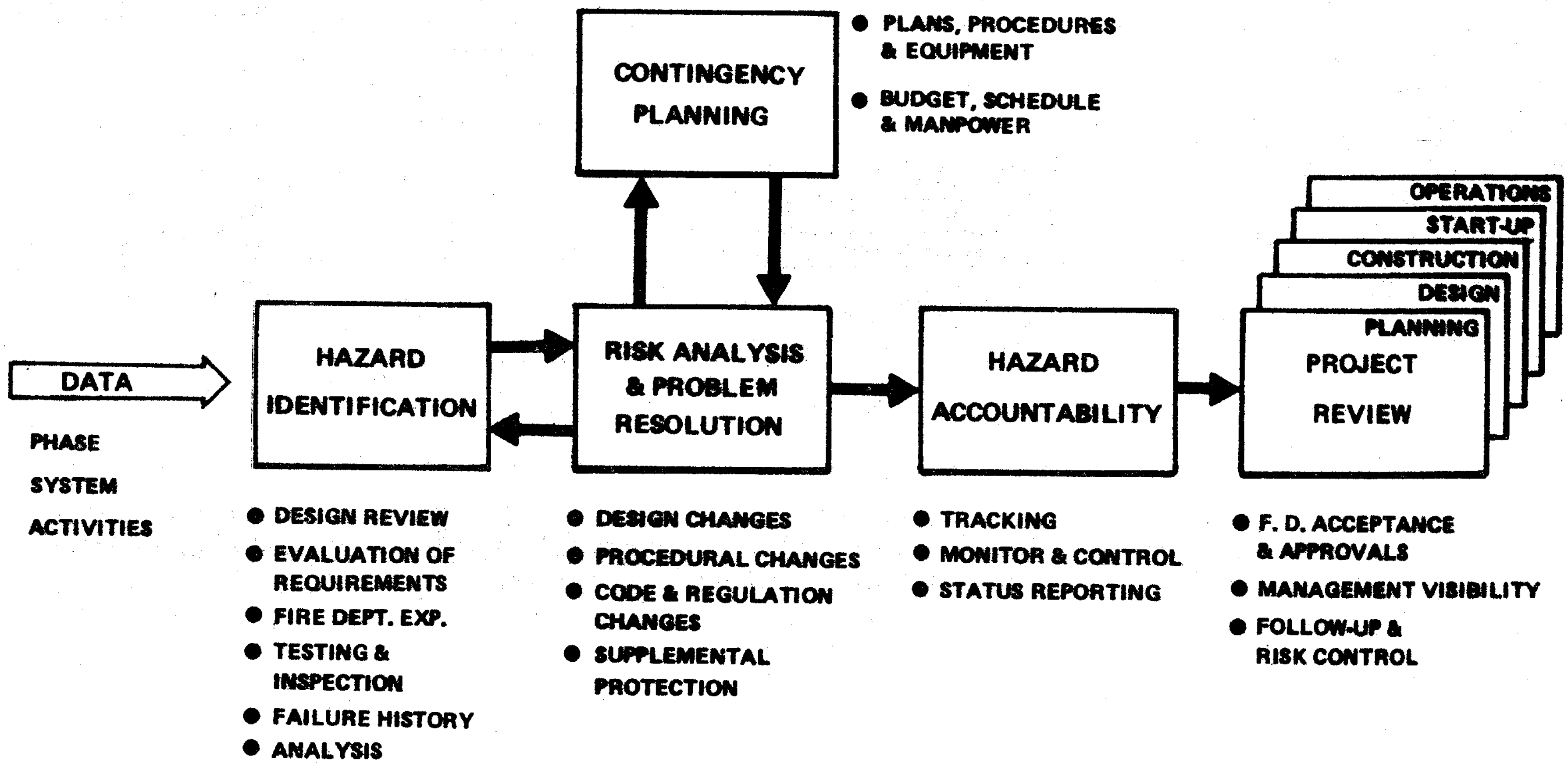

FIGURE 2-1

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RMS PHASE & PROJECT REVIEW IDENTIFICATION

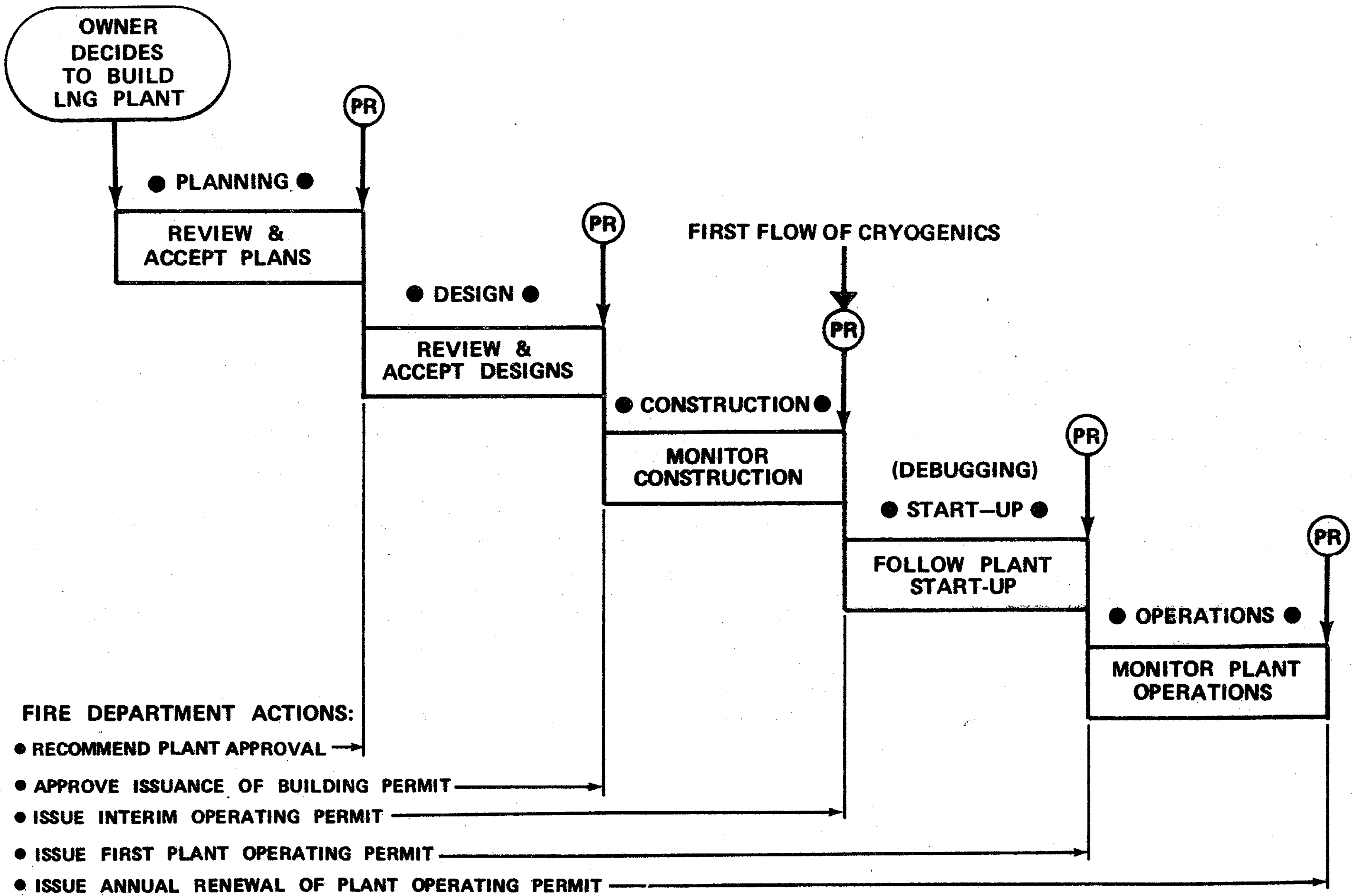

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FIGURE 2-2

2.2.2 (Cont'd)

and Terminals (or Department of Buildings) will review and accept the designs for the facility. The design phase activities lead to the recommendation by the Fire Department to the Department of Ports and Terminals (or Department of Buildings) relative to the issuance of a building permit(s) for the construction of the facility.

2.2.3 Construction Phase

During the construction phase the Fire Department and the Department of Ports and Terminals (or Department of Buildings) will monitor the construction through inspections and the acquisition of proof that the facility has been constructed and tested in accordance with approved plans and requirements. When satisfied the facility is ready for start-up operations, the Fire Department with the concurrence of the Department of Ports and Terminals (or Department of Buildings) will authorize the owner to commence with the cooldown of components and the flow of cryogenic fluids.

2.2.4 Start-Up Phase (De-Bugging)

During the start-up phase the Fire Department will monitor required reports relative to initial cooldown of components, flow of cryogenic fluids and other activities for operational safety. Upon completion of necessary changes or improvements to the facility and the procedures, the Fire Department will issue an operating permit for a standard one year period.

2.2.5 Operations Phase

Facility operations will be monitored and reports reviewed by the Fire Department on a continuing basis. The renewal of the operating permit will be annually. Prior to the issuance of the operating permit to the owner the Fire Department may request changes in facility or procedures as a requirement for renewal of the annual permit.

2.3 Systems Identification

A systems baseline is required to organize risk management activities into logical work packages for analysis and reporting purposes and allows correlation of data between LNG facilities. The systems identification from NFPA-59A, 1972 edition, has been selected for the purpose of systems definition in this instruction. The basic systems of a LNG facility are as described in the following paragraphs.

2.3.1 General Plant System

The general plant system includes the normal civil engineering features such as plant layout, siting construction and capacity of dikes, containment areas and berms, tanks, roads, equipment, drainage, grading, buildings, etc., plus those common plant features which overlap the remaining plant systems. Electrical features other than siting are excluded from this system.

2.3.2 Process System

The process system covers those mechanical functions associated with the liquefaction of pipeline gas for storage. Equipment included are pumps and compressors, boilers, heat exchangers, cold boxes, boil-off and flash gas systems. Included would be the functional operation of all the valves necessary to make the system operate.

2.3.3 Storage Container System

The storage container system consists of the storage tank structure and its functional elements. It interfaces with the general plant, transfer and fire protection and electrical and instrumentation systems.

2.3.4 Vaporization System

The vaporization system includes heated and/or ambient type vaporizers, relief devices, combustion air supply equipment and associated valves and piping.

2.3.5 Piping Systems and Components

The piping system includes the materials and fabrication of piping, selection of qualified valves and other components, location of isolation and blocking and proper workmanship of installing these. The operational functions of valves and pipe runs are normally considered to be in their respective operating system.

2.3.6 Instrumentation and Electrical System

The instrumentation and electrical system interfaces with all of the other systems in the provision of power, measurement control and communication. Specific interfaces may vary depending on the hardware but basically this system contains all of the electrical features of the facility.

2.3.7 Transfer System

The transfer system consists of that hardware and piping necessary to receive pipeline gas into the facility or the return of gas to the distribution system. It also includes that hardware to transfer LNG from barge or ship to the storage container and return.

2.3.8 Fire Protection System

Fire protection system consists of the water, dry powder, foam detection isolation and emergency shutdown, relief and venting systems installed throughout the facility. It also includes all of the portable and mobile equipment specified by the Fire Department. Plant supervisor, certificate holders and Fire Brigade training is considered to be a function of the Fire Protection System.

2.4 Elements of RMS

The elements of the RMS functional areas shown in Figure 2-3 are used to provide the necessary information to identify, analyze and control potential hazards. These elements are discussed in detail in Sections 3.0 through 7.0.

RISK MANAGEMENT SYSTEM OPERATION ELEMENTS

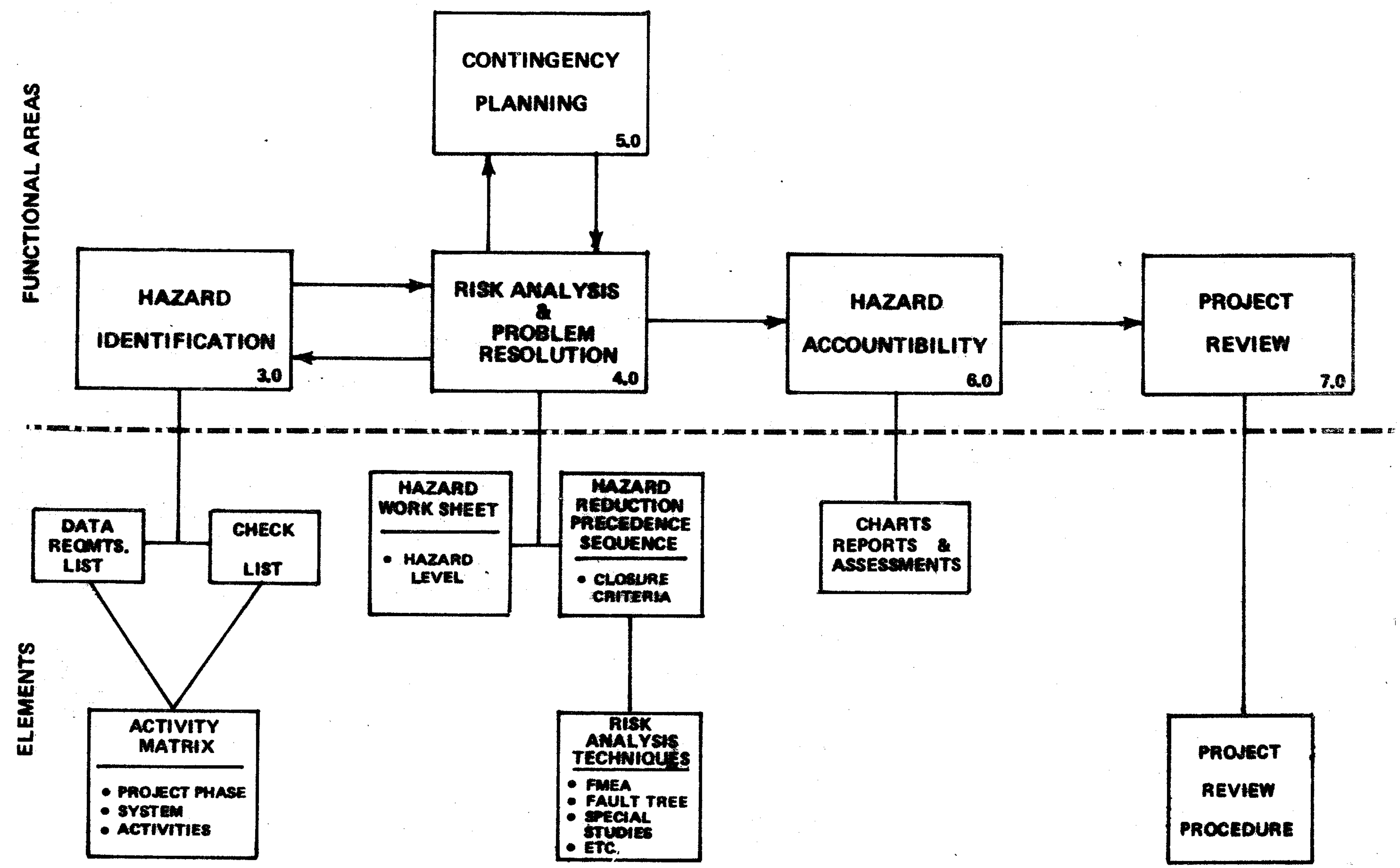

FIGURE 2-3

3.0 HAZARD IDENTIFICATION

The New York Fire Department LNG Regulation ________ and other applicable documentation identify requirements which the Fire Department deemed necessary for the planning, design, construction and operation of a LNG facility.

Other sources used by Fire Department personnel in the generation of additional requirements include but are not limited to the following:

a. Codes, Standards, Specifications, Procedures

b. Previous relatable Fire Department experience

c. Activities such as operations, testing, installation, maintenance, and training.

The requirements so identified, as a result of the above evaluation, will be arranged in several checklists and are utilized by Fire Department personnel during their review of the owner provided data. The number of checklists will be determined during the development of the Activities Matrix.

These requirements, which are imposed on the owner, form the basis for the hazard identification process. This process involves the comparison of owner submitted data with the applicable requirement. Non-compliance with the requirement constitutes an identifiable potential hazard. The hazard must then be further defined by risk analysis to reduce it to an acceptable level.

3.1 Project Activities Matrix

The Project Activities Matrix is a planning tool to identify the checklists required and to establish a numbering system for tracking of hazards within the RMS. The basic matrix is formed by placing the project phases as described in paragraph 2.2 across the top. The facility systems as described in paragraph 2.3 are placed vertically. This format shall be maintained for all facilities.

Within each phase Fire Department personnel shall identify specific activities that they are required to perform in monitoring LNG facilities. These activities should be definable work packages that stand by themselves and in which it would be desirable to have a checklist tailored to that work package. These activities are placed on the matrix as indicated in Figure 3-1. An "X" is entered on the matrix to denote a checklist requirement. The alpha-numeric identifiers assigned to systems, phases and phase activities are utilized to develop numbers for tracking purposes.

Appendix A is an example of a typical matrix with phase activities and checklist requirements shown. The level of detail of the activities identified in Appendix A may be to a lower level than actually necessary for Fire Department use. This is done purposely to indicate the RMS capability.

GENERAL PROJECT ACTIVITIES MATRIX

LNG PLANT SYSTEMS		NYFD LNG PLANTS ACTIVITIES				
		(P) PLANNING	(D) DESIGN	(C) CONSTR.	(S) START-UP	(O) OPER.
NO.	TITLE	A B C D E F	A B C D E	A B C D E	A B C D	A B C D E
1	GENERAL PLANT					
2	PROCESS					
3	STORAGE CONTAINERS					
4	VAPORIZATION					
5	PIPING & COMPONENTS					
6	INSTR. & ELECT.					
7	TRANSFER					
8	FIRE PROTECTION					

ACTIVITIES IN EACH PHASE TO BE DEFINED TO SUPPORT DEVELOPMENT OF LOGICAL WORK PACKAGES

WHERE APPLICABLE INSERT A "X" TO DENOTE A CHECKLIST REQUIREMENT

'GURE 3-1

3.2 Data Requirements List

During each phase of LNG facility development the owner is required to present certain documentation to Fire Department for review. Upon implementation of the RMS the Fire Department in consultation with the owner shall develop a data requirements list for each phase of the LNG project. This list should identify the data, who is to provide it and when it is needed. The data packages listed shall be identified to the checklist covering the review of the data.

Typical data requirements for each phase include but are not limited to the following:

a. Planning Phase

(1) Proposed Site Plans

(2) Facility/Process Description

(3) Thermal Radiation & Vapor Dispersion Study

(4) Fire Prevention Criteria/Document

b. Design Phase

(1) Site Plans

(2) Construction Drawings

(3) Relieving Devices Calculation

(4) Electrical Power Requirements

(5) Fire Protection System

(6) Flow Diagrams

(7) Schematics

(8) Test & Operation Plans

c. Construction Phase

(1) Qualification Records

(2) Inspection Records

(3) Test Results

(4) Modification Records

(5) Approvals/Affidavits

3.2 Data Requirements List (Cont'd)

d. Start-Up Phase

(1) Operating Procedures

(2) Training Plans

(3) Test Results

(4) Modification Records

(5) Affidavits

e. Operations Phase

(1) As-built Plans

(2) Reports

(3) Operation Procedures

(4) Training Status

(5) Modification Records

These data will be compared to the Fire Department requirements for compliance utilizing the appropriate checklist.

3.3 Checklists

The checklists are made up of individual items developed by Fire Department personnel using the regulation and other sources. The intent is to insure that all identified safety requirements have been met and that the LNG facility is designed, constructed, and operated to acceptable safety levels. Non-compliance with a requirement item constitutes a potential hazard necessitating corrective action within the RMS. The checklist form is shown in Figure 3-2 and the entries are described in Appendix B.

3.3.1 Quantity Requirements

The number of checklists is established through the development of the Project Activities Matrix (Appendix A). Each checklist will be as self-contained as is practical. Requirements affecting more than one checklist will be listed on each one. This will enable Fire Department personnel to refer to separate checklists when reviewing specific data being submitted by the owner for a particular system, phase and phase activity. Checklists can be further subdivided to represent individual areas of responsibility within the Fire Department. Checklists will be individually numbered.

CHECKLIST

NO.

PROJECT: Sample DATE:

SYSTEM: 2 Process PHASE: D Design

ACTIVITY: B Plant System Design Review

STATUS	HAZARD NO.	DESCRIPTION	REFERENCE
	2DB1	Is processing equipment containing LNG, flammable refrigerants or gases located outdoors	9.1
	2DB2	Are pumps and compressors constructed of materials suitable for temperature, pressure and usage, specified.	9.2.1
	2DB3	Are pumps and compressors valved for isolation	9.2.2
	2DB4	Do pumps and compressors installed in parallel have check valves in discharge lines	9.2.2
	2DB5	Are pressure relief devices located on the discharge of pumps and compressors	9.2.3
	2DB6	Does each pump have a [illegible] and relief valve to prevent overpressurizing the pump casing during [illegible]	9.2.4
	2DB7	Do pumps for use [illegible]°F have a means of precooling	9.2.5
	2DB8	Are foundations and sumps for cryogenic pumps constructed of incombustible materials	9.2.6
	2DB9	Do storage tanks for flammable refri- gerants and liquids comply with Chapter 19 of the Administrative Code.	9.3
	2DB10	Are boilers designed, fabricated, approved and certified per Administrative Building Code	9.4.2
	2DB11	Are shell and tube heat exchangers design- ed, fabricated, tested, inspected, approved and certified by the manufacturer per Tubular Exchange Mfrs. Association (TEMA) 1968 edition	9.4.3

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FIGURE 3-2 SIGNATURE

3.3.2 Identification Number

Each checklist requirement item will carry its own identification number and will be sequentially numbered within the checklist. The hazard identification numbering system consists of alpha-numeric characters and is described in Appendix B.

3.3.3 Form Utilization

The appropriate checklist(s) is selected and each requirement item is considered in turn in relation to the data submitted by the owner or by Fire Department inspection. Each requirement that does not apply to a LNG facility or data under consideration is marked "N/A" as not applicable.

The remaining listed requirements are considered applicable and the submitted data is compared to verify the requirement has been met. If it has been complied with a "Y" (Yes) is entered in the column. If it has not been complied with a "N" (No) is entered. Each non-compliance item will be an identified potential hazard and results in hazard accountability and risk analyses action being initiated.

4.0 RISK ANALYSIS

The main activity in the RMS consists of determining acceptable risk resolutions for the identified hazards. Of the several hazard and risk analysis techniques which can be utilized, only the most pertinent will be discussed in this instruction. The key to good risk management is determining the need for analysis, choosing the proper technique, recognizing the technical level of competence of the person(s) conducting the analysis and understanding the results of the analysis in terms of acceptance of the risk associated with the hazard. The RMS is structured around a basic technique titled "Hazard Reduction Precedence Sequence" which follows the criteria of "design to eliminate the hazard". This technique will be utilized primarily during the facility design phase but may also be applied during other phases to any identified hazard requiring corrective action. There are other analysis techniques which may be chosen to meet a particular risk analysis requirement, i.e., (1) Fault Tree Analysis, (2) Failure Mode and Effects Analysis, (3) Finite Element Analysis, (4) Stress Analysis, and structure analysis, (5) Special Studies. Several of these will be discussed in the appendices. The purpose of the discussion is to enable Fire Department personnel to recognize the need for a particular risk analysis technique to be performed, understand the results and ensure that the analysis was conducted by qualified persons. Figure 4-1 displays the hazard reduction precedence sequence logic.

4.1 Hazard Reduction Precedence Sequence

The most efficient way to resolve hazards is to design them out of the system. This may be accomplished by conducting thorough system analyses considering the possible trade-offs between various alternatives.

The actions which may be taken to eliminate or control hazards are listed in the order of precedence.

a. Design for Minimum Hazard - The major goal throughout the design phase shall be to ensure inherent safety through the selection of appropriate design features as fail-operational/-fail-safe combinations and appropriate safety factors. Hazards shall be eliminated by design where possible. Damage control, containment and isolation of potential hazards shall be included in design considerations.

b. Safety Devices - Known hazards which cannot be eliminated through design selection shall be reduced to an acceptable level through the use of appropriate safety devices as part of the plant, subsystem, or equipment.

HAZARD REDUCTION PRECEDENCE SEQUENCE LOGIC

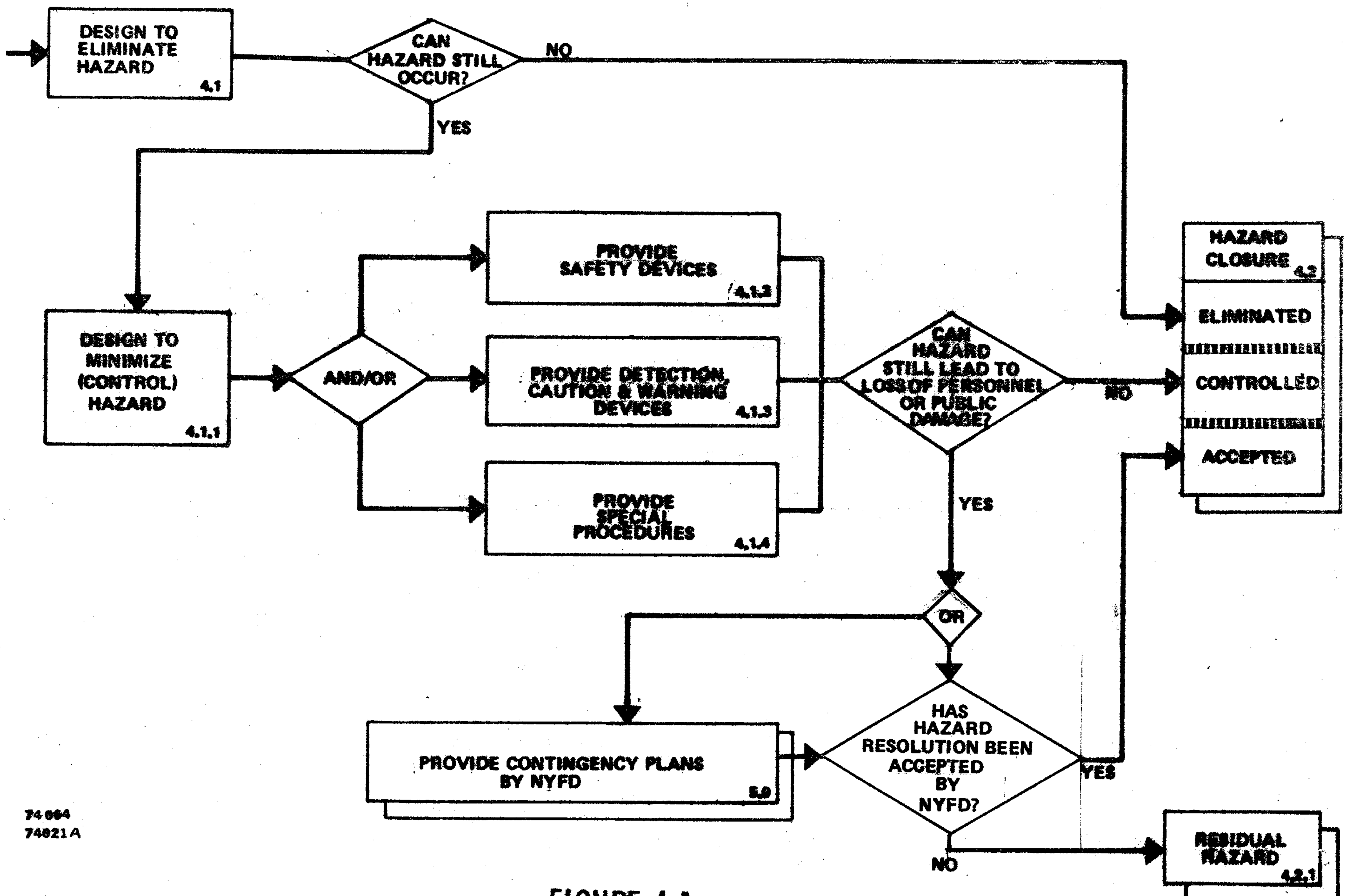

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FIGURE 4-1

4.0 RISK ANALYSIS (Cont'd)

4.1 Hazard Reduction Precedence Sequence (Cont'd)

c. Warning Devices - Where it is not possible to preclude the existence or occurrence of a known hazard, devices shall be employed for the timely detection of the condition and the generation of an adequate warning signal. Warning signals and their application shall be designed to minimize the probability of wrong signals or of improper personnel reaction to the signal.

d. Special Procedures - Where it is not possible to reduce the magnitude of an existing or potential hazard through design, or the use of safety and warning devices, special procedures shall be developed to counter hazardous conditions for enhancement of personnel and plant safety. Precautionary notations shall be standardized.

Personnel responsible for corrective action shall use the above sequence as a minimum or combination of these items for closure of each identified hazard.

4.1.1 Design for Minimum Hazard

The probability that a subsystem will enter a hazardous mode can be reduced by redesigning for higher reliability. Depending on the subsystem design and function, this can be achieved by the following methods.

4.1.1.1 Increasing Component Reliability

Component reliability can be increased to minimize subsystem complexity. To be effective, the components must have a high reliability which is a function of the design of the component, the manufacturing process, the degree and type of quality control, and how long a component has been stored in relation to its shelf life.

4.1.1.2 Redundant Components of Subsystems

An alternate to increasing component reliability is to provide redundant components or subsystems. The main advantage is that it involves only moderate engineering effort for identical components or subsystems. The reliability of redundant subsystems is rarely a straight mathematical progression. For example, two redundant amplifiers of reliability of 0.9 linked together with a changeover capability reliability of 0.5 provides an overall reliability of only 0.945 instead of 0.99. When redundant items are switched, an indication should be given, otherwise, operational and maintenance procedures could result in a loss rather than a gain in reliability.

4.0 RISK ANALYSIS (Cont'd)

4.1.1.3 Fail-Safe Devices

Fail-safe features are incorporated to cause the system to transfer from a high loss mode upon the occurrence of a component or subsystem failure. This inclusion of such a device does not reduce the probability of occurrence of failure as does redundant components, but alters the nature or magnitude of the loss. Care must be taken to ensure that the alternate mode indeed results in a lesser loss. The advantage of fail-safe devices is that complete subsystems need not be duplicated to provide acceptable levels of safety.

4.1.2 Safety Devices

Safety devices are incorporated to reduce the magnitude of the loss once a hazardous condition has been entered or identified. These include interlock switches, protective enclosures, safety pins, etc. Care must be taken to ensure that the operation of the safety device reduces the loss. Further safety devices should permit the facility or subsystem to continue operation despite the malfunction.

4.1.3 Warning Devices

Failure warning subsystems are technically a visual or audible portion of fail-safe features in which man is the responder. The effectiveness of such a system is a factor of man's ability to perceive and react.

4.1.4 Special Procedures

Hazardous conditions and operations require controls. To assure adequate control, the following are required:

a. The required personnel, equipment and safety support will be specified within the procedure.

b. Emergency procedures, when required, will be included to return equipment or subsystems to a safe condition, to control the hazard and to minimize personnel injury potentials.

c. Provisions for personnel evacuation will be established for hazardous operations and/or environments.

d. A safety requirement section is required which contains adequate overall safety controls and instructions to assure that optimum safety measures are integrated into the operations to prevent personnel injury or equipment damage. This section must also specify only hazards which will be encountered during the operations of the special procedure.

e. Notes, cautions and warnings will be included in the special procedure.

4.0 RISK ANALYSIS (Cont'd)

4.2 Hazard Closure

A hazard shall be considered closed only if:

a. Eliminated - the hazard has been eliminated by design and design accomplishment has been confirmed.

b. Controlled - the hazard has been reduced to an acceptable level in accordance with the Hazard Reduction Precedence Sequence described in Section 4.1 and this reduction has been verified by a successful completion of the required tests, analytical studies and/or training activities.

c. Accepted - the hazard has been assessed and the risk reduced to a level which is accepted by the Fire Department or other responsible agencies.

4.2.1 Residual Hazard

A residual hazard is a hazard for which safety or warning devices and/or special procedures have not been developed or provided for counteracting the hazard.

4.3 Hazard Two-Way Worksheet

The hazard two-way worksheet shown in Figure 4-2 is used to record and resolve hazards.

The hazard two-way worksheet is a means of communication between the person responsible for identifying a hazard from the checklist and the person responsible for resolving or reducing the hazard. The hazard number and closure status information is used in tracking and accounting portions of the Risk Management Systems.

The top portion of the hazard two-way worksheet form is completed by the Fire Department. The lower portion of the form is completed by the assignee. Instructions for completing this form are explained in Appendix C.

HAZARD TWO-WAY WORKSHEET

N.Y.F.D.

HAZARD NUMBER:	HAZARD LEVEL:	PREPARED BY:	DATE:
2DB3	2	C. B. Smith	10/23/74

REFERENCES: Requirement - Regulation 9.2.2
Source - Dwg. No. PS 228-01-0631, Rev. 0A

HAZARD: No. 1 600 HP compressor is not isolated for maintenance

HAZARD DESCRIPTION:

Outlet piping Dwg. does not call for an isolation valve.

ASSIGNED TO:

RESOLUTION:

Revise Dwg. to provide isolation valve in outlet piping.

SAMPLE

CLOSURE DOCUMENTATION:

Dwg. PS 229-01-0631, Rev. 0B

RESPONSIBLE ENGINEER		HAZARD STATUS					CONCURRENCE			
		OPEN		CLOSED						
NAME	DATE	IN-WK.	RES.	ACCEP.	CONT.	ELIM.	FIRE DEPT.	DATE	ASSIGNEE	DATE
R. B. Jones	10/25/74					X	A. W. Brown	11/4/74	F. G. Williams	11/4/74

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FIGURE 4-2

5.0 CONTINGENCY PLANNING

Contingency planning is defined as the planning of those activities related to public safety which must be performed by the Fire Department over and above the installed facility protection systems. It consists of the preparation of plans for supporting hazardous operations and disaster plans in event of a catastrophic failure. It also includes the programming of additional manpower and equipment required over and above the facility protection provided by the owner.

The nature and magnitude of contingency plans are dependent directly on the level of protection provided by the owner. These items shall be considered beginning with the planning phase. The owner's plans, designs and procedures shall be fully evaluated for Fire Department impact. When Fire Department participation is required the need for contingency planning is established. Contingency plans shall be identified to the affected hazard analysis worksheet and shall become a condition of closure for that hazard.

Contingency plans relating to Fire Department resources such as manpower and equipment will be identified and tracked in a manner to support internal planning.

6.0 HAZARD ACCOUNTABILITY

6.1 General

An integral part of the RMS is the dissemination of data to the cognizant management personnel for visibility and corrective action initiation.

In the Risk Management System, the accountability baseline is the identified potential hazards resulting from non-compliance with requirement items listed on the checklists and the resolution status recorded on the hazard two-way worksheet.

The accountability system will track, control and status all identified hazards. It will provide this information in a timely manner serving as a linking element between requirements and resolution accomplishment. The reports, trend charts and summaries will be the data reviewed periodically and at the certification reviews.

6.2 Status Reporting

The system will be capable of reporting the status of all identified hazards. It will recognize the various hazard levels, identify residual hazards (catastrophic, critical) and corrective action status. This information will be presented in various reports, charts, lists, summaries (Figure 6-1) to cognizant Fire Department management. The choice of display(s) is predicated upon user requirements.

6.2.1 Trend Charts

These charts will be time oriented showing the number of open/closed hazards, hazard levels and will enable management to determine what action needs to be taken to eliminate/reduce all open hazards to an acceptable level prior to the certification review.

6.2.2 Summary Listings

This is a complete listing of all hazards and the closure status. It will identify each hazard by number and provide a ready reference for total corrective action status.

6.2.3 Key Problem Summary

This will list each key issue or problem by number, identify the person/organization responsible for the resolution, show the expected action being taken to resolve the problem and provide a date when the resolution must be finalized.

TYPICAL STATUS REPORTS

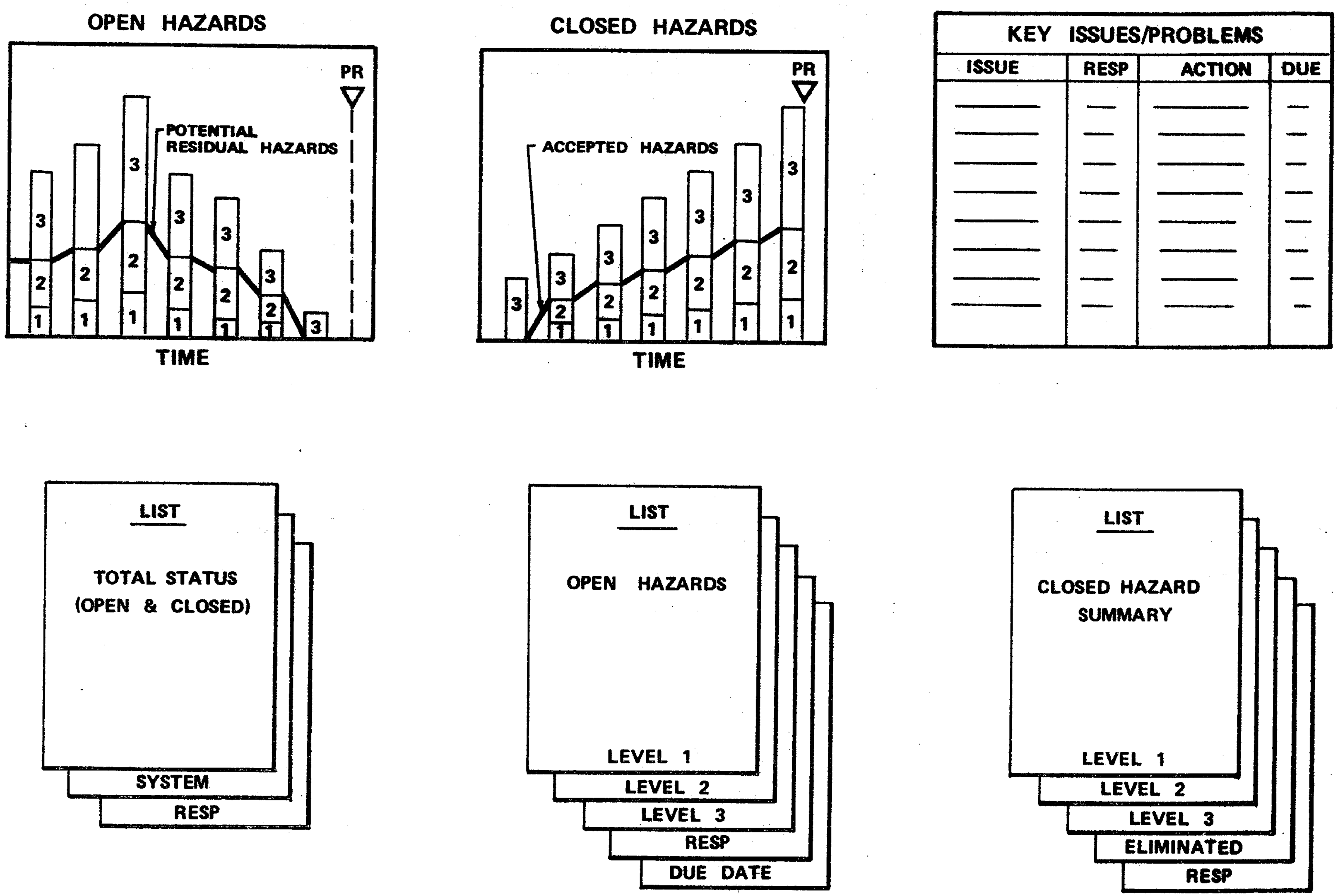

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FIGURE 6-1

7.0 PROJECT REVIEWS

The Project Review is a meeting between the owner and the Fire Department in which the status of the owner's compliance to Fire Department requirements is reviewed. Fire Department acceptances and approvals are based upon the results of these reviews. Project Reviews are the culmination of project phases under the RMS. They will provide the basis for the following Fire Department actions:

a. Planning Phase - Report to the Board of Standards and Appeals or the agency having jurisdiction of the Fire Department's acceptance and/or objections to the company's plans.

b. Design Phase - Report to the Department of Buildings or Department of Ports and Terminals of the Fire Department's acceptance and/or objections to the Design of the facility.

c. Construction Phase - Approval to the owner to commence cryogenic fluid operations.

d. Start-up Phase - Issuance of the first annual operating permit.

e. Operations Phase - Issuance of each annual renewal of the operating permit.

The Project Review meeting will be chaired by the Chief of Fire Prevention, N. Y. Fire Department. In attendance will be Fire Department personnel along with the owner, his engineer of record and other supporting personnel.

Material to be presented in the Project Review shall be prepared by the assigned project engineer in the office of the Chief Inspector, N. Y. Fire Department Division of Fire Prevention and the engineer of record. Close cooperation between the two will assure that the presentation will limit subject matter to key issues and assure decisions can be made without lengthy detailed discussions.

The basic order of procedure of the Project Review with an approximation of percentage of time devoted to it is as follows:

a.	Review of Owner's Status and Plans	25%
b.	Hazard Resolution Status	10%
c.	Key Issues/Problems Assessments	50%
d.	Fire Department Acceptance of Risks	5%
e.	Summary	10%

7.0 PROJECT REVIEWS (Cont'd)

7.1 Review of Owner's Status and Plans

The Project Review will commence with a review by the owner as to the status of the facility and his plans for meeting Fire Department requirements. This presentation will vary as to phase and will include, but not be limited to, the following past performance and future planning information:

a. Facility descriptions and processes

b. Status of approvals from other Governmental agencies

c. Design, construction, modification activities

d. Amount of LNG processed

e. Number of ship or barge operations

f. Significant problems

g. Corrective actions taken

h. Special study or analysis results

7.2 Hazard Resolution Status

The hazard resolution status presentations in the Project Review is the same data that is used for hazard accountability reporting and described in Section 6.0. These include selected trend charts, summary listings and key problem summaries as shown in Figure 7-1. The data presented should make it clear to the attendees that the routine problems have been corrected and the major problems have been identified. These major problems are to be discussed individually.

7.3 Key Issue/Problem Assessments

A one sheet assessment will be prepared for each major key issue or problem. These will be presented for discussion during the Project Review. The assessment is prepared regardless of whether the Fire Department has previously accepted the risk or not. The assessment should substantiate the Fire Department's position and not be prepared in a form which would require extensive discussions during the review meeting. Fig. 7-2 is a sample form for the assessment.

7.4 Fire Department Acceptance of Risks

The Fire Department's acceptance of risks would be in parallel with the above assessment discussions. The Fire Department must accept the resolution of the risk as stated or classify it as a residual hazard for which no workable solution has been found. Residual hazards are always tracked until resolved.

TYPICAL PROJECT REVIEW PRESENTATIONS

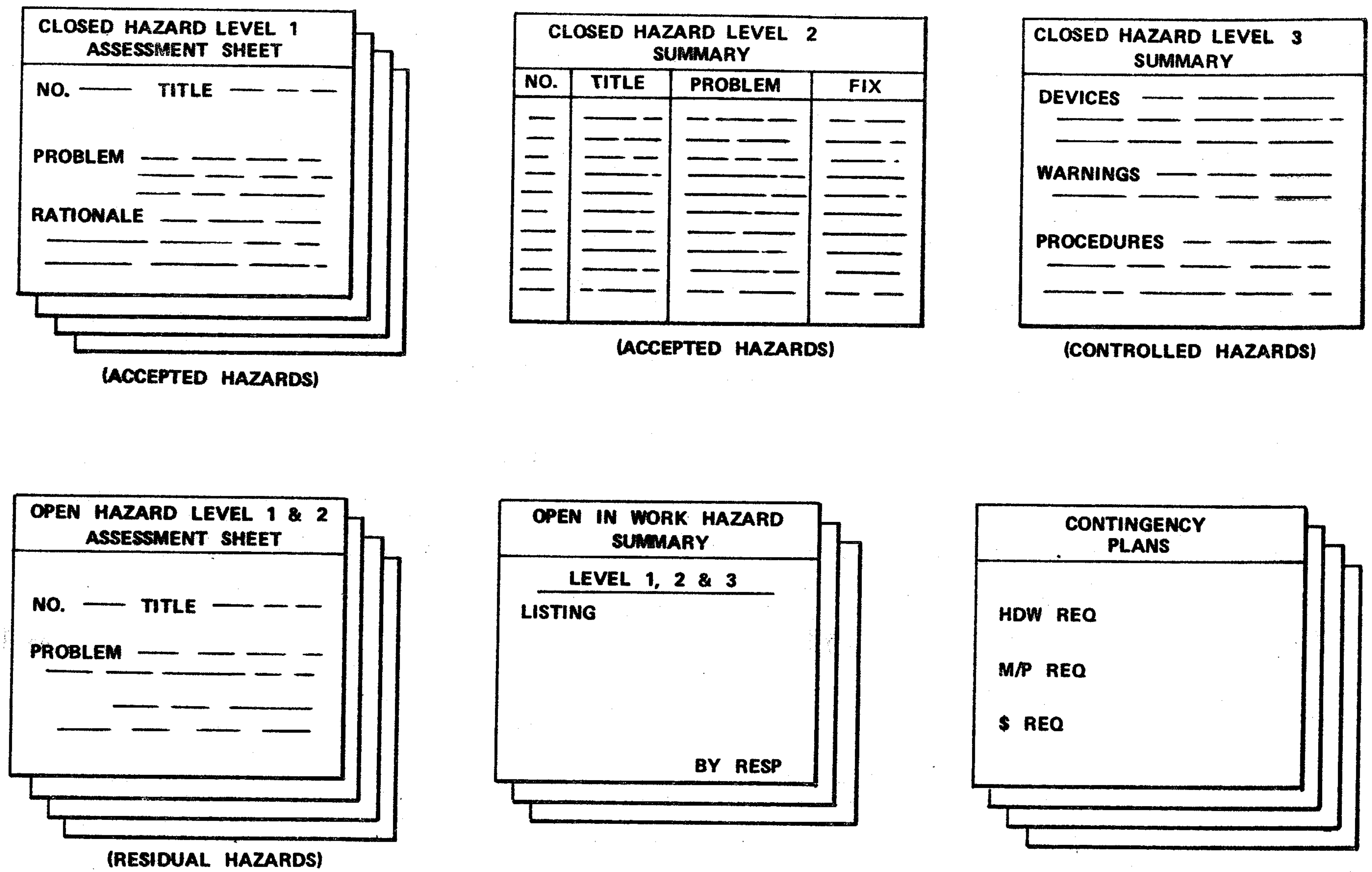

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FIGURE 7-1

HAZARD/PROBLEM ASSESSMENT SHEET

HAZARD/PROBLEM NUMBER:	TITLE:	
HAZARD/PROBLEM:		
INVESTIGATION/RESOLUTION STATUS:		
ASSESSMENT:		
REPORTED BY:	DATE:	STATUS AS OF:

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FIGURE 7.2

7.0 PROJECT REVIEWS (Cont'd)

7.5 Project Review Summary

If the owner has met all of the requirements for that particular phase acceptance or approval by the Fire Department will be straight forward. However, if there remains some open hazards or other problems which result in a qualified approval by the Fire Department, these must be recorded. At the end of the Project Review these will be summarized and placed in a form by which the Fire Department can give to the owner a qualified approval. These items will be considered open for the next phase and tracked under the RMS as any other unresolved hazard until corrected.

Appendix A

APPENDIX A

INSTRUCTIONS PROJECT ACTIVITIES MATRIX

The attached completed matrix chart (Figure A-1) is a typical example of the activities which may occur during each phase. An "X" has been entered to indicate a requirement exists for completing a specific checklist associated with the system phase and phase oriented activity.

A typical selection of activities and associated tasks are described below:

A.1 PLANNING PHASE ACTIVITIES

A. Site Arrangements

Review and acceptance of planning data for:

- Adaptability of site from the standpoint of community, soils, access, roads, utilities, transportations, etc.
- Relative location of major plant elements.

B. Plant Operating Concepts

Review and acceptance of planning data for:

- Plant systems operational flows.
- Sizing, materials, operational capabilities of critical components.
- Fail-safe concepts.
- Critical areas requiring protection.

C. Fire Protection Plans

Review and acceptance of planning data for:

- The individual fire protection systems.
- Degree of protection provided.
- Activation concepts.
- Fire Department interface definitions.

D. Personnel Training and Qualification Plans

Review and acceptance of planning data for:

- Certification of workmen (welders).
- Certification of plant personnel.
- Fire brigade.

E. Contingency Planning

Develop plans for Department provided:

- Facilities
- Equipment
- Training

PROJECT ACTIVITIES MATRIX CHART

NYFD LIQUIFIED NATURAL GAS PLANT ACTIVITIES

LNG PLANT SYSTEMS		(P) PLANNING					(D) DESIGN				(C) CONSTRUCTION					(S) START-UP				(O) OPERATIONS				
		SITE ARRANGEMENT	PLANT OPERATING CONCEPTS	FIRE PROTECTION PLANS	PERSONNEL TRAINING PLANS	CONTINGENCY PLANNING	SITE DESIGN REVIEWS	PLANT SYSTEM DESIGN REVIEW	FIRE PROTECTION SYSTEM DESIGN REVIEW	DESIGN FOR CONTINGENCIES	SITE CONSTRUCTION APPROVALS	PLANT SYSTEM INSTALLATION & TEST	FIRE PROTECTION SYSTEM INSTL. & TEST	ACQUISITION OF CONTINGENCY HARDWARE	CERTIFICATION OF CONSTRUCTION	OPERATING PROCEDURE APPROVAL	START—UP OPERATIONS	MODIFICATIONS	CERTIFICATION OF START—UP OPERATIONS	OPERATING PROCEDURE REVIEW	OPERATIONS DATA REVIEW	PERIODIC TEST OPERATIONS	MODIFICATIONS	CERTIFICATION OF OPERATIONS
NO.	TITLE	A	B	C	D	E	A	B	C	D	A	B	C	D	E	A	B	C	D	A	B	C	D	E
1	GENERAL PLANT	X			X	X	X			X	X			X	X	X		X	X	X			X	X
2	PROCESS		X					X				X					X				X	X		
3	STORAGE CONTAINERS		X					X				X					X				X	X		
4	VAPORIZATION		X					X				X					X				X	X		
5	PIPING AND COMPONENTS		X					X				X					X				X			
6	INSTR. AND ELECT.		X					X				X					X				X	X		
7	TRANSFER		X					X				X					X				X			
8	FIRE PROTECTION			X					X				X				X				X	X		

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FIGURE A-1

A.2 DESIGN PHASE ACTIVITIES

A. Site Design

Review and acceptance of design data for:

- Community protection, soils, access, roads, utilities, transportation, etc.
- Location of major Plant elements.
- Structural integrity of designs.

B. Plant Systems Design

Review and acceptance of design data for:

- Operational flows
- Use of acceptable materials
- Qualification of critical components
- Structural integrity verification
- Fail-safe capability
- Critical Failure Point identification
- Operating procedures adequacy

C. Fire Protection Systems Design

Review and accept design data for:

- Individual fire protection systems.
- Degrees of protection verification.
- Activation methods.
- Compatibility with Fire Department interfaces.
- Operating procedures adequacy.

D. Designs for Contingencies

Prepare or acquire designs for:

- New facilities
- New equipment
- New training

A.3 CONSTRUCTION PHASE ACTIVITIES

A. Site Construction Approvals

Monitor construction activities and verify that the plant is built according to plans for:

- Locations of major plant elements.
- Use of materials specified.
- Workmanship

A.3 CONSTRUCTION PHASE ACTIVITIES (Cont'd)

B. Plant Systems Installation and Test

Monitor plant systems installation activities and verify that the equipment is according to plans for:

- Use of acceptable materials.
- Identification of critical components.
- Qualification of critical components.
- Workmanship
- Proof pressures
- Procedures
- Controls
- Instrumentation

C. Fire Protection System Installation and Test

Monitor plant fire protection system installation and test and verify that the equipment is according to plans for:

- Use of acceptable materials
- Degree of protection offered
- Activation controls
- Fire Department interfaces
- Procedures

D. Acquisition of Contingency Hardware

Monitor procurement activities for contingency hardware to verify it will meet requirements for:

- Additional Fire Protection facilities
- Additional Fire Protection equipment
- Interfaces with Plant Systems

E. Certificate of Designs and Constructions

Acquire certification that the design meets all Fire Department requirements:

- Company
- A&E
- Engineer of Record
- Other New York City Departments
- Test Data
- Plant Survey
- Any other agency approvals
- All requirements have been met
- Certified personnel available

A.4 START-UP PHASE ACTIVITIES

A. Operating Procedure Approval

Review procedures for completeness.

B. Start-Up Operations

Assure all systems, equipment and personnel are ready.

C. Modifications

Review those affecting critical systems for completeness. Verify all modifications accounted for.

D. Certification of Start-Up Operations

Review records for completeness:

- Test data
- Construction approvals/affidavits

Verify data available:

- Plant survey
- Any other agency approvals
- All requirements have been met
- Certified personnel available

A.5 OPERATIONS PHASE ACTIVITIES

A. Operating Procedure Review

Verify all required procedures are current and complete.

B. Operations Data Review

Fire Department Permit As-Built approved plans available.

C. Periodic Test Operations

Plans/procedures available for any test/retest/purging operations.

D. Modifications

Verify all modifications complete and modification records current.

E. Certification of Operation

All required approvals, affidavits, certificates received, and all required reports available.

Appendix B

INSTRUCTIONS FOR CHECKLIST

The checklist shown in Figure B-1 lists the requirement items to be compared with owner submitted data. The instructions for completing the form are as follows:

1. PROJECT - The identification of the specific LNG facility.
2. DATE - Enter the date the checklist was initiated.
3. SYSTEM - The identifying number and title.
4. PHASE - The identifying letter and title.
5. ACTIVITY - The identifying number and title.
6. STATUS - Enter compliance with requirement notation: N - Requirement not complied with; Y - Requirement complied with; N/A - Requirement not applicable.
7. HAZARD NO. - Enter the assigned number. The number consists of four or more alphanumeric digits:

1st. Digit is numeric and identifies the major system:

No.	System
1	General Plant
2	Process
3	Storage Containers
4	Vaporization
5	Piping & Components
6	Instrumentation & Electrical
7	Transfer
8	Fire Protection

2nd. Digit is an alpha notation identifying the phases:

Letter	Phase
P	Planning
D	Design
C	Construction
S	Start-Up
O	Operations

3rd. Digit is an alpha notation identifying the activity within each phase:

PLANNING PHASE

Letter	Activity
A	Site Arrangement
B	Plant Operating Concepts
C	Fire Protection Plans
D	Personnel Training Plans
E	Contingency Planning

CHECKLIST

11 NO.

PROJECT: 1 DATE: 2

SYSTEM: 3 PHASE: 4

ACTIVITY: 5

STATUS	HAZARD NO.	DESCRIPTION	REFERENCE
6	7	8	9

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SIGNATURE 10

FIGURE B-1

DESIGN PHASE

Letter	Activity
A	Site Design Reviews
B	Plant System Design Review
C	Fire Protection System Design Review
D	Design for Contingencies

CONSTRUCTION PHASE

Letter	Activity
A	Site Construction Approvals
B	Plant System Installation & Test
C	Fire Protect. System Installation & Test
D	Acquisition of Contingency Hardware
E	Certification of Constr.

START-UP PHASE

Letter	Activity
A	Operating Procedure Appr.
B	Start-Up Operations
C	Modifications
D	Certification of Start-Up Operations

OPERATIONS PHASE

Letter	Activity
A	Operating Procedure Review
B	Operations Data Review
C	Periodic Test Operations
D	Modifications
E	Certification of Operations

4th. Digit is numeric - assigned sequentially to identify each item:

Sample Hazard Number is:

```
2 D B 4
| | | └──── Sequentially assigned item number
| | └────── Plant System Design Review
| └──────── Design Phase
└────────── Process
```

8. DESCRIPTION - Short statement identifying requirement to be met.

9. REFERENCE - Enter requirement reference.

10. SIGNATURE - Fire Department individual responsible for Checklist sheet.

11. Checklist Page Number

Appendix C

INSTRUCTIONS FOR HAZARD TWO-WAY WORKSHEET

HAZARD TWO-WAY WORKSHEET

The two-way worksheet shown as Figure C-1 is used to record and resolve hazards. Instructions for completing the form are as follows:

1. NYFD - This section of the form is to be prepared by the person in the Fire Department responsible for identifying the hazard.

2. ASSIGNED TO: - This section of the form is to be prepared by the party responsible for resolving the identified hazard. The responsible party is identified in this entry.

3. HAZARD NUMBER: - Enter the hazard number from the open item on the checklist.

4. HAZARD LEVEL: - The assigned hazard level is entered here. The hazard levels are to be defined by 1, 2 or 3 in accordance with the following:

   1. Catastrophic - A hazardous condition where a failure could result in loss of life or prolonged loss of facility capability, or

      a hazard wherein no time or means are available for corrective action, or

      a problem whose resolution would be on the level of concern of the Chief of Fire Prevention, New York Fire Department.

   2. Critical - A hazardous condition where a failure could result in serious injury to personnel or temporary loss of facility capability, or,

      a hazard that may be counteracted by emergency action performed in a timely manner, or

      a problem whose resolution would be on the level of concern of the Chief Inspector, Division of Fire Prevention, New York Fire Department.

   3. Controlled - A hazard that has been counteracted by appropriate design, safety devices, alarm/caution and warning devices or special automatic/manual procedures, or

      a problem whose resolution would be on the level of the assigned Project Engineer in the office of the Chief Inspector, Division of Fire Prevention, New York Fire Department.

5. PREPARED BY: - Enter the responsible Fire Department engineer who has identified the hazard.

6. DATE: - Enter the date the two-way worksheet was initiated.

7. REFERENCES: - Enter the requirement reference such as Regulation for LNG or NFPA 59A and the source document, drawing procedure, etc., which was used to identify the hazard.

HAZARD TWO-WAY WORKSHEET

N.Y.F.D. (1)

HAZARD NUMBER (3)	HAZARD LEVEL: (4)	PREPARED BY: (5)	DATE: (6)

REFERENCES: (7)

HAZARD: (8)

HAZARD DESCRIPTION: (9)

ASSIGNED TO: (2)

RESOLUTION: (10)

CLOSURE DOCUMENTATION: (11)

RESPONSIBLE ENGINEER (12)		HAZARD STATUS (13)					CONCURRENCE (14)			
		OPEN		CLOSED						
NAME	DATE	IN-WK.	RES.	ACCEP.	CONT.	ELIM.	FIRE DEPT.	DATE	ASSIGNEE	DATE

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FIGURE C-1

(8.) HAZARD: - Provide a short concise statement of the hazard.

(9.) HAZARD DESCRIPTION: - Enter a short, narrative statement describing the hazard in as much detail as is necessary to understand the problem.

(10) RESOLUTION: - The requirements for eliminating, reducing or otherwise controlling the hazard are developed by the firm or person who was assigned the problem in conjunction with appropriate design, operational or responsible personnel. The agreed-to-resolutions are listed in this block. In developing these resolutions the following preferred sequence (described in Analysis and Reduction Activities, Para 4.2) is used:

a. Eliminate hazard.

b. Minimize hazard by reducing probability of occurrence and/or reducing the potential effects.

c. Provide safety devices.

d. Provide means for detection and caution and warning to the operating personnel.

e. Provide special procedures for controlling hazard and/or emergency action.

For each hazard which cannot be eliminated, all the appropriate resolutions (b) through (e) must be considered.

(11) CLOSURE DOCUMENTATION: - Enter here the document, drawing, procedure, work-order, etc., which resolves the identified hazard. This block may also be utilized by the Fire Department for making an entry such as an acceptance letter, etc., which the assignee requires for closure of the hazard.

(12) RESPONSIBLE ENGINEER: - Enter name of person completing block (11) and date entry was made.

(13) HAZARD STATUS: - Open hazards are identified by placing a check mark (✓) in the IN-WK (In Work) block or entering a 1 or 2 in the Res. (Residual) block. The numbers 1 and 2 are defined in (4) above.

Closed hazards are identified by: Entering a 1 or 2 in the Accept. (Acceptance) block, entering a 3 in the Cont (Controlled) block, or entering a check mark (✓) in the Elim. (Eliminated) block. The numbers 1, 2 and 3 are defined in (4) above.

(14) CONCURRENCE: - Enter name of person in Fire Department who has the approval authority for the identified hazard and date of approval, also enter name of assignee who has the approval authority and date of entry.

Appendix D

APPENDIX D

D.1 RISK ANALYSIS TECHNIQUES

There are several analysis techniques which may be employed to determine the amount of risk. Some of the more common techniques are stress and structural analyses. There are many other analysis techniques. For simplicity, only two of the more usable techniques for determining hazards will be discussed. These two useful analysis techniques are Fault Tree Analysis and Failure Mode and Effect Analysis.

D.2 FAULT TREE ANALYSIS - INTRODUCTION

The fault tree is an evaluation of an "undesired event". The approach is to work "backward" from the undesired event to its causes. This approach identifies not only the hardware failures which led to the undesired event, but also the "non-hardware" causes such as human error. Thus, the decision-making data from a Fault Tree Analysis are identification of critical events.

Fault trees are prepared by degreed engineers with a strong background in mathematics and statistical analysis. The engineer must be capable of compiling data on equipment operation and evaluating products to assure successful operation at the proper time. This involves research and development design, mathematical and system analysis techniques. The engineer must be capable of investigating failure causes ensuring proper resolution of analysis techniques. The engineer must establish design, manufacturing and operating practices which will ensure reliable products and advise management on new developments and requirements.

D.2.1 Description of Fault Tree Analysis

A fault tree is a tool for analysis of complex systems. They are useful for evaluation of system failures caused by multiple component failures.

Fault trees serve three purposes, which are:

a. As a tool for accident analysis, a fault tree aids in determining the possible causes of an accident. When properly used, the fault tree often leads to discovery of failure combinations which otherwise would not have been recognized as causes of the event being analyzed.

b. The fault tree serves as a display of results. If the design is not adequate, the fault tree can be used to show what the weak points are and how they lead to the undesired event. If the design is adequate, the fault tree can be used to show that all conceivable causes have been considered.

c. For reliability analysis, the fault tree provides a convenient and efficient format for the problem description.

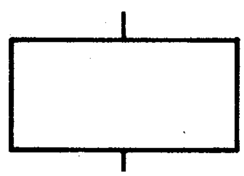
D.2.1.1 Fault Tree Development

Fault Tree Analysis is the functional development of a specified undesired event through logic statements of the causative conditions. The fault tree methodology, therefore, initially involves the identification of a specific undesired event. A logic diagram, utilizing the established symbology for event and logic gate representation, is then developed in which all events or system conditions which are considered necessary and sufficient to lead to the occurrence of the system event are identified and related logically to one another as they actually occur in the system. When this development is completed, the analyst is presented with a qualitative logic network in which all failure paths, both singular and multiple, and all combinations of events and conditions which could produce the undesired event are graphically represented.

D.2.1.1.1 Fault Tree Symbols

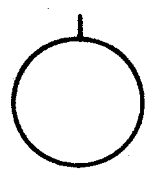
The various types of events used in Fault Tree Analysis are represented by the following symbols:

Rectangle



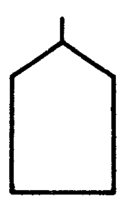
The rectangle identifies an event that results from the combination of fault events through the input logic gate.

Circle



The circle describes a basic fault event that requires no further development. Frequency and mode of failure of items so identified is available and can be substantiated.

House



The house indicates an event that must occur due to normal operating conditions in the system. The house does not indicate a fault event.

D.2.1.1.1 Fault Tree Symbols (Cont'd)

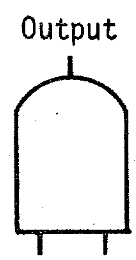
Diamond

The diamond describes a fault event that is considered basic in a given fault tree. The possible causes of the event are not developed either because the event is of insufficient consequence or the necessary information is not available.

The following logic gate symbology is used in the fault tree development as logic "connectors" between the various events. There must always be a specific event description between logic gates.

"AND" Gate

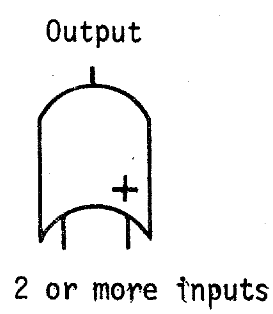
The logical "AND" function is symbolized in the fault tree as follows:



The "AND" gate describes the logical operation whereby the coexistence of all input events is required to produce the output event.

"OR" Gate

The logical "OR" function is symbolized in the fault tree as follows:



The "OR" gate defines the situation whereby the output event will exist if one or more of the input events exists.

D.2.2 Fault Tree Evaluation

After the fault tree has been logically constructed and the necessary input data acquired, the quantitative evaluation can be made. The objective is to establish the probability of occurrence of the undesired event and to evaluate the relative contribution of each indicated fault event. With this information, the analyst can identify the dominant fault paths, compare the probabilities of occurrence with any numerical goals and management can make the decision as to whether or not corrective action is warranted.

D.3 FAILURE MODES & EFFECTS ANALYSIS

A Failure Modes and Effects Analysis is a qualitative means of evaluating the reliability, maintainability and safety of a design by considering potential failures and the resulting effects on a system. Basically, the analysis involves the identification and tabulation of the ways (or modes) in which a part, component or system can fail, as for example: A ball bearing may fail from normal wearout or abnormal wearout, or brinelling. The effect of each mode is identified, as abnormal wearout will cause increased noise and vibration, with rapid wearing of bearing parts and eventual destruction of bearing and seizing of the pump.

An FMEA is usually performed by engineers with a degree in either math, physics, AE, CE, EE, IE, ME or engineering oriented psychology. The engineer must be capable of: (1) the development of techniques, data requirements, data acquisition and controls to assume that the system(s), subsystem(s) or component(s) will perform its intended function within acceptable limits of probability through analysis, prediction, allocation, reviews and specification compliance audits, (2) Participating in design reviews, collect and analyze failure data, conduct failure analysis and determine corrective action requirements.

In using the analysis the identified effect may be different depending on the purpose for which the analysis is to be used. In reliability analysis the effect considered is the effect on the performance of system function. In maintainability analysis, the effects include the symptoms by which a failure could be identified (as temperature of the bearing) and the additional parts needing replacement due to damage because of the failure of the part. In Safety analysis, the additional effects considered would be damage to adjacent equipment and possible danger to personnel.

Failure mode and effect analysis is a systematic procedure for determining the basic causes of failure and defining actions to minimize their effects. It may be applied at any level of assembly (from a complete plant to parts). In each case, the mode is described as the way in which the unit fails to perform its function. For a pump, failure to produce the proper volume and pressure of fluid may be due to loss of suction or bearing seizure.

D.3 FAILURE MODES & EFFECTS ANALYSIS (Cont'd)

The analysis is performed to isolate and identify weaknesses in the design. The final step in the analysis is the determination of ways to eliminate or reduce the probability of incidence of critical failure modes to improve the design. Since funds and time are never unlimited, corrective action involves the assignment of priorities of effort based on relative seriousness of the consequences (effects) of failure.

D.3.1 Uses of Failure Modes & Effects Analysis

D.3.1.1 Application to Reliability Prediction

A method used in predicting the reliability of mechanical systems is similar to the method used in predicting the reliability of electronic systems. A reliability block diagram, which is a pictorial representation of a failure effects analysis, is a basic part of each method. In electronic systems, the blocks are identified as parts or components. Failure modes or mechanisms are seldom referred to. In mechanical systems, however, the blocks are identified by modes of failure, for each part or component. In mechanical system reliability predictions, reference is made to "types of failures of parts in specific application" rather than "parts failure rates".

It is evident that an accurate, precise definition of failure is necessary. The definition of component failure is as needed as the definition of system failure, in particular where the components are those parts of the system to be used in the system prediction and failure rate data is available for them. The controlling factor in determining the meaning of component failure is the tolerance of the system to component variation and/or inoperability. This tolerance varies with the type and timing of component performance variation, e.g., a sticking valve may or may not affect system performance, depending on whether the valve sticks open or closed and when the sticking occurs. Therefore, component failures in mechanical systems often cannot be defined except in reference to that system. A brief outline of a method used in predicting the reliability of a large mechanical system is as follows:

Step 1: The system is divided into a number of subsystems which can be more easily dealt with. As this prediction method involves predicting the reliability of each subsystem and then recombining these predictions to arrive at the overall system reliability, the division must take place on a functional basis. Careful and precise system and subsystem definition is a necessary prerequisite. The block diagram is used to coordinate and record the functional breakdown. Numbers are usually assigned to the blocks for ease of cross-reference. System definition includes time-line analysis, environments and definition of failure at each block level.

Step 2: A detailed study is made of the schematic engineering drawings for each subsystem in order to determine all of the significant modes of failure. Knowledge of the effect of component failure as well as the

D.3.1.1 Application to Reliability Prediction (Cont'd)

Subsystem and system reaction to failure of the component is necessary. Definition of failure is an essential portion of the analysis, but it cannot be treated in general terms, i.e., failure means operation not in conformity with some well-stated performance requirements.

Step 3: All of the component failure mechanisms are determined which could lead to each of the failure modes. Failure mechanisms are the basic physical causes of failure and failure modes are the reactions to failure mechanisms. Failure modes can result from the occurrence of any one of a set of failure mechanisms or from the simultaneous occurrence of two or more particular failure mechanisms.

Step 4: A summary of all the reliability information obtained and analyzed from the design schematic drawings is made. This is accomplished by tabulating all of the failure modes and making an analysis to demonstrate the relationships between component and system malfunctions (Figure D-1).

Step 5: The information compiled above is used to prepare a reliability model.

Step 6: The probabilities of occurrence of the failure modes are determined and are displayed as numerical inputs. This type of data is obtained from manufacturers or as estimated from prior experience. While in most cases, the values of failure rates are approximate, this computation has great power in comparing alternatives.

Step 7: The system reliability prediction is generated utilizing the reliability model and the probabilities associated with the occurrence of each failure mode to arrive at a numerical value representing the overall reliability of the system under investigation.

D.3.1.2 Application to Maintainability Prediction

The prediction of a Mean-Time to Repair (MTTR) requires first the identification of the parts subject to failure and an estimate of the probable frequency of such failures. The Failure Modes and Effects Analysis requires the creation of just such a list. The documentation provides the necessary design discipline for methodically evaluating the probability of failure and the results thereof for trade-off between reliability and maintainability to achieve the system availability requirements. The failure modes approach refines the prediction of reliability and maintainability to a consideration of the various mechanisms of failures that may be operable.

Figure D-2 provides an example of a Failure Modes and Effects Analysis for maintainability evaluation (1). The equipment is a steam turbopump. Figure D-3 continues the analysis of tasks to the individual task elements.

JET ENGINE FAILURE RATE ANALYSIS

ASSEMBLY NAME COMPRESSOR ROTOR

ASSEMBLY DRAWING NO. 107R491G7

ITEM NO.	COMPONENT NAME	DRAWING NUMBER	MODE OF POSSIBLE FAILURE	FAIL RAPID OR GRAD	EFFECT ON: COMPONENT	EFFECT ON: BASIC ENGINE	POWER LOSS EFFECT: MAX.	MIL.	95%	90%	NONE	F/R FAIL 10^6 HR	DESIGN LIFE HRS.
1A1c22	Shaft, Stub - Compressor Rotor Front (1 req'd)	619E799P1	Rupture	R	Shaft Breaks	Rotor Failure Ruptured Casing Other Engine Damage or Destruction	X	X	X	X		1	10000
			Yield	G	Unbalance	Compressor Rubs Motor Misalignment Hi Vibs Power Loss Blade Damage	X	X					
			Spline Wear or Shear	G	Wear Spline Shears	Loss of Accessory Drive System Engine Shutdown	X	X					
			Bearing Surface Wear	G	Wear	Rotor Misalignment Compressor Rubs Hi Vibs.	X						

DESIGN CONSIDERATIONS

STUB SHAFT, COMPRESSOR ROTOR FRONT

1. Design temperature — 300°F
2. Design Rotational Speed — 7850 RPM
3. Material of Component: Chrome, Molybdenum, Vanadium Alloy Steel; G.E. Specification B5F5, C50T7F.

Material properties at design temperature:

a. .02% yield strength if 107,000 psi with 10% reduction for material deviations.

b. Not in creep range.

4. Stress calculations covered in Memorandum 60 DM79C—[illegible].
5. Part subjected to magnetic particle inspection per material specification.

When supplied as a spare, part is subjected to overspeed test of 8100 RPM for 3 minutes with loading comparable to being tested in a compressor rotor assembly.

FIGURE D-1

FAILURE MODE & EFFECT ANALYSIS

ITEM	NAME	MODE OF FAILURE	CAUSE OF FAILURE	EFFECT OF FAILURE	OTHER COMPONENTS DAMAGED
13 14	WHEEL – TURBINE ASSY. SEGMENT – GUIDE	RUBBING	EXTREME BEARING, THRUST RING OR BALANCE RING WEAR	INCREASED NOISE & VIBRATION WITH BLADE DAMAGE AND POSSIBLE EXTENSIVE DAMAGE TO OTHER COMPONENTS	USUALLY WOULD BE DAMAGED SIMULTANEOUSLY
16	PACKING – THROTTLE VALVE	NORMAL WEAR-OUT	FRICTION WITH VALVE STEM	EXCESSIVE STEAM LEAKAGE	17
		ABNORMAL WEAR	GLAND NUT ADJUSTED TOO TIGHT	POOR CONTROL, DAMAGED VALVE STEM	
17	VALVE – THROTTLE	NORMAL WEAR-OUT	FRICTION WITH LINER & STEAM EROSION	POOR PRESSURE CONTROL	NONE
		ABNORMAL WEAR	GLAND NUT ADJUSTED TOO TIGHT	EXCESSIVE STEAM LEAKAGE	
18	LINER – THROTTLE VALVE	NORMAL WEAR-OUT	FRICTION WITH THROTTLE VALVE	POOR PRESSURE CONTROL	NONE
MISC.	BOLTS, GASKETS, ETC.	LOOSENESS, LOSS OF MATERIAL, ETC.	OVER-STRESS FATIGUE, ETC.	USUALLY REQUIRES SERVICE WHICH CAN BE PERFORMED AT CONVENIENCE	USUALLY NONE

FIGURE D-2

REPLACEMENT TASK DIAGRAM

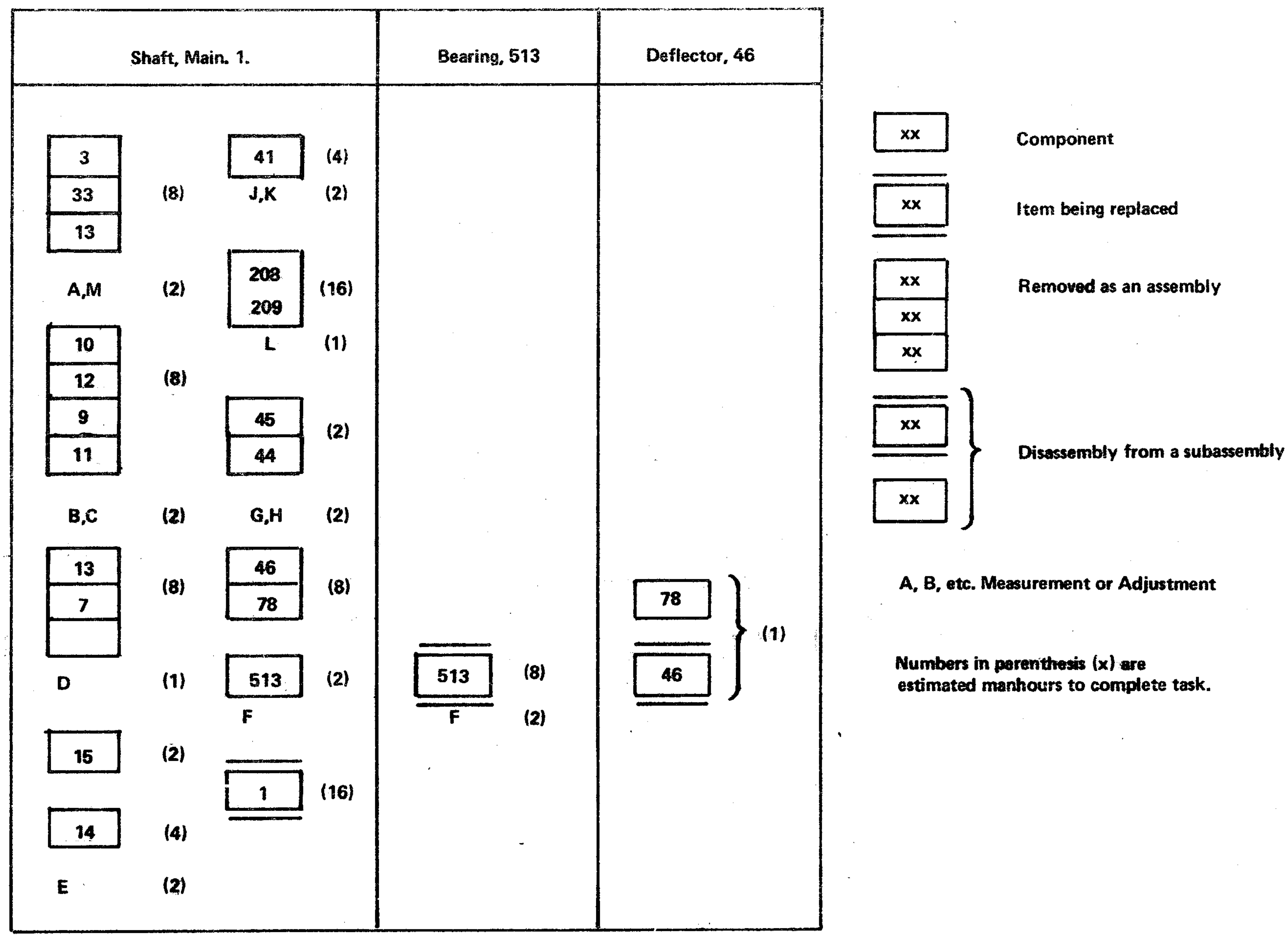


FIGURE D-3

D.3.1.3 Application to Safety Analysis

The safety aspects of equipment failure are investigated by a Safety Analysis. Safety analysis is not restricted to human safety, but includes the effect on the total system, associated or adjacent equipment and personnel in the vicinity either associated with the system or casual. Starting from the identification of the expected failure modes, the effect on the adjacent and associated equipment is evaluated. An example is given in Figure D-4.

D.3.2 Time of Analysis

Failure modes and effects analysis starts from the top down. System functions and failure modes are first considered in abstraction, then expanded down to the subsystem, component and part level.

It is initiated during the concept phase of a design, then as the design becomes more clearly defined, is expanded concurrently with the design. The effectiveness of the analysis in system tradeoffs is made possible by its availability at the time design decisions are required. The analysis documentation must be kept dynamic and current with the design clear through the final test and delivery of the equipment. It must be available for use as design changes are proposed to assure that the discipline provided keeps control of the effects of changes in reliability and maintainability.

In the failure effect analysis of the structure, no written analysis accompanies the reliability mode. During the design, the structure undergoes an analysis involving design and stress calculations, which can be classified as single failure effect analysis. On the basis of this analysis, the structure is strengthened/redesigned at those points where possible failure will occur. For this reason, it can be stated that the complete structure has been designed to withstand normal loads without failures which will result in loss.

D.4 CAUTIONS IN RISK ANALYSIS

Although various risk analysis techniques may be available, these should not be regarded as tools to be applied to every design problem, particularly those where a definite alternative is clearly the proper solution. Statistical and analytical techniques are not a replacement for common sense or experience. Employment of a mathematical technique may indicate that the probability of an undesirable event occurring due to a given set of circumstances is one in ten thousand. If the event would cause loss of the system and can be precluded without significant degradation of performance, why accept the risk? The concept of establishing an acceptable level of risk can result in acceptance of unnecessary risk. The purpose of risk analysis is to expose hazards and minimize or preclude risk. Recognize that predictions may be inaccurate by a magnitude when an event is associated with human behavioral variances.

SAFETY ANALYSIS

Item	Component	Failure Mode	Mode Probability	Failure Effect	Corrective Action
1a13	Reservoir, hydraulic	Burst	.0001	Explosive fragments	Relocate to area C–7; Provide shielding for Electronic equip. Area C–9
				Fire	Relocation minimizes danger of ignit.
				System Failure	Risk acceptable
				Toxic fluid spray	Increase Ventilation
1a14	Accumulator	Burst	.01	Same as reservoir	Relocate to area C–6.

FIGURE D-4

D.5 METHODOLOGY AND CONCEPTS

D.5.1 General

The necessity for risk analysis stems from the need to know whether a design is potentially capable of complying with a predetermined goal or requirement or if design changes are necessary. Testing can be used to further develop designs or to verify the attainment of goals and requirements. Analysis and testing are mutually independent.

SECTION IV

ADP REQUIREMENTS

NYFD

RISK MANAGEMENT SYSTEM

LNG

TABLE OF CONTENTS

1.0 DATA REQUIREMENTS SUMMARY

Section IV provides a baseline definition of input and output requirements for an Automatic Data Processing (ADP) system utilizing information from the Risk Management System (RMS). The ADP system for the RMS may be a sub-system within an existing Management Information and Control System provided the program permits data flow and production of reports on a reasonable non-interference basis.

The need for developing an ADP system for the RMS is predicated on the quantity of data to be operated on and the frequency and types of reports required. The primary advantage of the ADP system is the capability to handle large quantities of uniformly inputted data and then rapidly sort, count, display and summarize this information, in a variety of different reports.

Figure 4-1 is a summary of the reports and data field requirements. The detailed report formats and the final alpha-numeric symbology chosen to display the information must be developed to meet the specific needs of the user and the program capabilities of the ADP system available.

A general description of the purpose of each report and definitions of the data fields follow.

2.0 RMS REPORT DESCRIPTIONS

All reports are to be prepared to cover specific LNG facility projects. Working reports need to be produced only to cover the current phase activities. The report titles given in the following paragraphs will include the identification of the facility and phase. For example: the first report described may have a full title of "Consolidated Edison Project, Operations Phase - Checklists".

2.1 Checklists

This report is the master checklist file for a particular facility. It will be produced only on request. The checklists will be presented by activity to match the manner in which they will be used.

2.2 Checklist Open Items

This report is the working report for the person who is recording the compliance to checklist items. It should be produced monthly and will also be activity oriented.

2.3 Master Data File

This report is a dump of all data in the master file. It is used primarily for control of the data system. A sort by system has been specified to enable review of total system inputs for a single project. This report is only produced on request.

2.4 Project Data Summary

This report provides a summary of the status of a project. It is produced monthly for the current phase.

ADP SYSTEM REQUIREMENTS SUMMARY

	DATA FIELD ELEMENTS \ REPORT TITLE	1 CHECKLIST	2 OPEN CHECKLIST ITEMS	3 MASTER DATA FILE	4 PROJECT DATA SUMMARY	5 ACTIVITY HAZARD CLOSURE STATUS A OPEN	5 ACTIVITY HAZARD CLOSURE STATUS B CLOSED	6 HAZARD LEVEL CLOSURE STATUS A OPEN	6 HAZARD LEVEL CLOSURE STATUS B CLOSED	NUMBER OF DIGITS
1	PROJECT IDENTIFICATION	1	1	1	1	1	1	1	1	2
2	PHASE	2	2	3	2	2	2	2	2	1
3	SYSTEM	3	3	2	3	3	3	6	6	2
4	ACTIVITY	4	4	4	4	4	4	7	7	1
5	HAZARD NUMBER	5	7	5	5	8	8	8	8	2
6	HAZARD NOMENCLATURE			X	X	X	X	X	X	40
7	HAZARD LEVEL			X	X	7	7	5	5	1
8	HAZARD STATUS	X	5/6	X	X	5/6	5/6	3/4	3/4	2
9	REQUIREMENT REFERENCE	X	X	X	X	X	X	X	X	12
10	ORIGINATOR			X	X	X	X	X	X	10
11	DATE ORIGINATED			X	X	X	X	X	X	6
12	ASSIGNED TO			X	X	X	X	X	X	10
13	DATE ASSIGNED			X	X	X	X	X	X	6
14	REMARKS			X	X	X	X	X	X	100
15	CHECK LIST DESCRIPTION	X	X							300
	REPORT FREQUENCY	AR	M	AR	M	W	M	W	M	

NOTES:
AR–REQUESTED M–MONTHLY
W–WEEKLY X–REQUIRED DATA
NUMBERS INDICATE SEQUENCE OF SORT.

74021

FIGURE 4-1

2.5 Activity Hazard Closure Status

The purpose of this report is to highlight the open hazards. The report is prepared in two sections. The open hazards are produced weekly while the closed hazards are produced monthly. This report is activity oriented to follow closure by activity.

2.6 Hazard Level Closure Status

The purpose of this report is to highlight open hazards by hazard level and to provide the data for status reports. The open hazards are produced weekly while the closed hazards are produced monthly. This report will provide lists of open items by level to enable the proper attention to be directed for closure. This report should be programmed to provide counts of hazards by hazard level and hazard status for reporting purposes.

3.0 DATA FIELD DEFINITIONS

3.1 Project Identification

A specific LNG facility, i.e., Brooklyn Union, Distrigas, etc.

3.2 Phase

The phase code (P,D,C,S, & O) which identifies a particular project phase during the development of a LNG facility; Ref: Para. 2.2, Sec. III.

3.3 System

Numeric code identifying a major LNG facility system (1-8); Ref: Para. 2.3, Sec. III.

3.4 Activity

Alpha code identifying a particular activity occuring within each phase (A, B, C, etc.). Ref: Para. 3.1 and Appendix A, Sec. III.

3.5 Hazard No.

Alpha-numeric number code is the discrete hazard identification number assigned during the development of the various checklists. Ref: Para. 3.3 and Appendix B, Sec. III.

3.6 Hazard Nomenclature

The short title which most aptly describes the hazard.

3.7 Hazard Level

Numeric code identifies the assigned hazard level of the particular hazard (1, 2, 3). Ref: Appendix C, Sec. III.

3.8 Hazard Status

A double alpha code will identify whether a particular hazard is open or closed.

Field	Code
Open	
In Work	OW
Residual	OR
Closed	
Accepted	CA
Controlled	CC
Eliminated	CE

Ref: Appendix C, Sec. III

3.9 Requirement Reference

Data field which identifies the source of the hazard identification number.

3.10 Originator

Coded identification of person originating hazard worksheet.

3.11 Date Originated

Date hazard worksheet was originated.

3.12 Assigned To

Person assigned action by Hazard Worksheet.

3.13 Date Assigned

Date Hazard Worksheet was assigned for action.

3.14 Remarks

Enter appropriate comments.

3.15 Checklist Description

Work description of checklist item.